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Making fast to an ocean telegraph cable that has just been fished up from the bottom

MAINTAINING OCEAN TELEGRAPH CABLES **[See page 388]**

The Structure of the Skeleton in Invertebrate Animals*

Some Description of the Simplest Elements Constituting the Morphological Unit

By Lucien Cayeux, Professor in the College of France and in the National Agronomic Institute

PALEONTOLOGISTS have always shown a preference for devoting themselves to the morphological study of fossils and with a few rare exceptions have overlooked the inherent importance of the micro structure of their skeletons. In making this statement I do not forget the capital rôle played by the microscope in the diagnosis of the Foraminifera and the distinction between the Perfora and the Imperfora (W. B. Carpenter) which bears witness to the evidence that in this group at least, the idea of the structure is the very basis of the classification. I might also cite the case of the Rudista, which by the diversity of the elements in the skeleton have furnished us with valuable means of differentiation (H. Douville).

The sea-urchins are no less interesting, particularly with regard to their appendices, of which it has been possible to remark that "the difference of the microstructure of the spines in a single genus (the *Cidaris*, for example), is so considerable that a careful examination of them will yield sufficient data to determine the species." (Zittel.)

It is not my purpose here to describe the microstructure of the various groups of the Invertebrates. I will confine myself to the observation that this question, which is both absorbingly interesting and full of promise, should be further investigated even in the types which have been most studied, such as the Foraminifera, and that it is practically untouched as regards many others.

In my opinion Paleontologists would do well to devote much attention to this subject, which to me seems comparable to the histologic and anatomic elements of the tissues which do not belong to the skeleton, and to put it on an equal footing with morphology in the classification of the Invertebrates.

But this, however, is not the subject of the present article. At the request of the *Revue Générale des Sciences* I purpose to give here a brief résumé of a problem which is not less fundamental than the preceding, though of narrower scope, since it concerns the materials of a universal nature which enter into the skeletons of the Invertebrates. I shall deliberately ignore the combinations of these materials, confining myself to the description of the simplest elements, in other words those which constitute the morphological or optical unit.

As a preface to such a task it is proper to acknowledge our indebtedness to two English scientists, W. B. Carpenter (2) and H. C. Sorby (3), who, quite independently discovered a number of years ago, the essential features of what is known upon this subject. I have been led to pursue and to complete their analytical researches mainly with petrographic and paleooceanographic aims in view. It is my intention here to give a brief outline of the present state of the subject closing with a synthetic view of the known facts. Leaving entirely aside all question of their chemical and mineral composition, the elements of the skeleton in Invertebrates may be reduced to a very small number of types.

At the bottom of the scale among animal and vegetable organisms we find creatures built upon a unique model: these are the silicious Radiolaria and the Diatoms. However complicated the shell of a Radiolarius it is never possible to resolve it into its constituent elements. The entire structure practically consists of a single piece. A simpler architecture cannot, in fact, be imagined.

Among certain Foraminifera, other one-celled organisms, the unit is a *granule* of some sort. To these belong the agglutinant species which borrow from the medium in which they exist, the materials they require to build their shells.

The *spicule* unit is found only among the lower Invertebrates. It forms the skeleton in the Sponges, the Halcyons, and the Holothurids, and is also found either singly or associated in a continuous skeleton, in certain Radiolaria.

In the vast group of the Echinoderms with the exception of the Holothurids, the spicules are replaced by *calcareous parts of alveolar structure*. The articulations of the Crinoids, the plates of sea-urchins, the ossicles of the Stelleridae, and the appendices of the Echinidae are also units, from the optical point of view, which it is impossible to separate into smaller elements. This unique optical orientation, together with an alveolar form of structure which secures great economy of material belongs particularly to the Echinoderms.

The *fiber* is the constituent element of the skeleton in a large number of the Foraminifera, the Coelentera, and the calcareous Bryozoaria; it likewise takes part in the formation of the tegumentary apparatus of the Crustacea. Like the spicule, but in no way to the same degree, the fiber changes in aspect from the surface of one group to that of another.

In more highly organized Invertebrates we observe the appearance of other forms of construction, such as the prism, the lamina, etc. The true prism, that is, the solid prism of geometric form, which is never resolved into smaller elements, is peculiar to the articulated Brachiopods and to certain Lamellibranches. It is far from forming an integral part of the shell in all Molluscs, as the treatises on paleontology would have us suppose. In the Rudista it is replaced by a false prism. Originally the unit was a very long *prismatic cell*. In most cases it has been obliterated through fossilization and transformed into a solid prism. Prismatic cells whether full or empty have no proper individuality, therein differing from the true prisms of the Molluscs and the Brachiopods.

Another type of false prism is in reality a *foliated prism*, or better yet it may be termed a *fascicle of lamellae*. In this species the unit is always a complex of very fine lamellae, forming by their union a sort of fascicles which are irregular in form and which are branching and are connected with each other. Many Lamellibranches exhibit this structure in their external layer.

But if the morphological characters of false prisms justify in a certain measure the terminology which has wrongly been applied to them, the same thing is not true for the element which forms the shell of the Gastropods. This is nothing other than a *foliated lamina*. Instead of having the form of a rod it has that of a plane. Of a thickness similar to that of the true prisms of the Lamellibranches, the lamina may be decomposed into numerous extremely thin foliae, and its aspect may vary altogether according to the direction taken by the sections. However, sections perpendicular to the laminae exhibit to a greater or less degree the facies of prisms.

Finally another unit is properly called a lamella. This is the element found in what is called the lamellous layer of the Lamellibranches. This unit has an individuality proper to itself from the morphologic point of view. I mean that it is entirely different from any group constituting units of a superior order, such as laminae and foliated prisms. This type of lamellae is found in some of the Brachiopods and in the Cephalopods; it is this which constitutes the internal layer of the Lamellibranches.

To sum up the matter, *the list of materials from which the skeletons of Invertebrates are constructed is rather scanty, although the skeletons are infinitely polymorphous.*

* * * * * * *

If, after having passed in review the elements made use of in the building of the skeleton of Invertebrates, we study their distribution, and better still their mode of employment from one end of the series to the other, we are able to deduce a law of great importance.

In the one celled organisms, such as the Radiolaria, the microstructure is ideally simple. Instead of being formed of material adjoined to each other, the shell behaves, in effect, like an absolutely undifferentiated vitreous mass, whatever the degree of complexity of its morphological characters.

At first sight the Foraminifera exhibit a certain amount of complexity. While it is true that we may observe different structures among them, these never coexist in the same individual. In the agglutinant types the granular structure reveals to us a peculiarly primitive process of construction; the organism confines itself, in fact, to gathering about itself materials which are unconnected and of varied nature and piling them up in a chaotic manner. With the development of the fibrous structure so widely found in the group we meet with a differentiation of the substance of the shell itself. In the Perfora, in which this is to be observed, the fibers, which are always very short, are arranged perpendicular to the surface and in a single row. From this is derived a very great degree of uniformity such as is found in no other Invertebrates of fibrous structure.

The Sponges, which are remarkable for the infinite morphological variety of the elements of the skeleton, have for the most part silicious and calcareous spicules, all constructed upon a single and very simple model. In many of those most widely found the silicious spicules can never be resolved into elements grouped in one manner or another. In short, each spicule is *one* throughout its whole mass. The same thing is true of calcareous forms, each of which comports itself in polarized light like a single crystal.

The Echinoderms, with their coarse perforated materials, display fundamentally great simplicity of microstructure, for all the parts are so many individuals, irreducible into smaller elements under the microscope.

When the fibrous structure again comes into play it is diversified by the variety of facies and especially by the disposition of the fibers, these being capable of being arranged in many ways. It is in this respect that the Coelentera, the Crustacea, and the Bryozoaria exhibit a relatively great degree of complexity when compared with the fibrous shelled Foraminifera.

In the Brachiopods the uniformity of structure disappears, and several types of architecture can be distinguished. This is true, *a fortiori*, of the Molluscs, in which we have discovered a whole series of constituent units, either associated or not in the same individual. It is quite evident that in these the microstructure of the shell attains its maximum complexity.

The reason for the great diversity of structure displayed so markedly in one and the same group of Molluscs is really mysterious in the present state of our knowledge. I am inclined to believe that this fact is most profoundly involved in the history of these organisms.

In short, *if we consider the main facts concerning the microstructure of the skeleton it is obvious that it becomes increasingly complex as we ascend the scale among the Invertebrates.*

The question which here engages our attention is no less interesting from another point of view. It is extremely curious to observe that the most beautiful structural effects visible under the microscope are produced by means which appear ideally simple under our laws of optics. Let me cite in proof of this the fact that the silicious Radiolaria, organisms of exquisite beauty, possess an opal shell which is absolutely without differentiation, and that a rod of the sea-urchin, an openwork structure constructed with consummate art, while usually revealing an extraordinary complexity, resolves itself mineralogically into an ordinary piece of calcite, oriented in the same way at all points. As a general rule when the material of the skeleton can be decomposed into very small elements elegant and harmonious sections cease to exist. From numerous observations along this line a law has been evolved to which I believe there is no exception. *The microstructure of the skeleton of Invertebrates becomes complex at the expense of the beauty of the sectional view.*

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As a result of the preceding observations it is legitimate to conclude that a vast domain in the science of fossils has been far too neglected in the past. It is to be hoped that philosophic Paleontology, which has always been held in great honor in our land, will reserve henceforth a less limited space in its speculations for the Invertebrates. Valuable discoveries may be looked for by devoted and persevering investigators along this line.

NOTES.

1. I have outlined the main features of this subject after having made a systematic study of the organisms regarded as constituent elements of the sedimentary rocks.

L. Cayeux: Introduction to the Petrographic Study of the Sedimentary Rocks. (Memoir Intended to Explain the Geologic Map drawn in detail of France, 1916, vol. 1, Text VIII, p. 524; Atlas, 56 pl.).

2. W. B. Carpenter: On the Microscopic Structure of Shells (14th Report Brit. Assoc., 1845, p. 1-24, and 17th Report, 1848, p. 93-134).

3. H. C. Sorby: Anniversary Address of the President (Quart. Journ. Geolog. Soc., vol. XXXV, 1879, p. 56-93).

*Translated from the *Revue Gen. des Sciences* (Paris) for the SCIENTIFIC AMERICAN SUPPLEMENT.

Steam Turbine Development*

Tendencies of Progress and Future Possibilities

THE rapid strides made in central station practice in this country have brought about many developments of turbines for land purposes in sizes that have gone beyond European practice, and very remarkable steam engine performances have been obtained by the principal manufacturers. Very material advances have been made in the development of the high-speed alternating-current generators, which have permitted turbines to be designed more appropriately for the volumes of steam involved. Today, 5,000-kw., 60-cycle machines have been built for operation at 3,600 r.p.m., while in the year 1900 electrical engineers looked askance at such speeds even for 500-kw. units, and regarded 1,800 r.p.m. as the more desirable speed for this capacity and frequency. Improvements in condensing apparatus have also contributed to the development of the turbine, bringing ordinary available vacua from 26 in. to 29 in.

Early turbines had their low pressure elements designed for vacua not much over 26 in. Today, all turbines are designed to expand steam at their point of best steam consumption to 29 in. vacuum.

Today the maximum capacities of generators at given speeds are as great as the capacities for which the turbine can be conveniently designed. In other words, the turbine ceases to be a machine of too high speed for general application. It may be designed for its best speed and connected direct to the generator in the case of alternating-current machinery for all but the smaller sizes below 500 kilowatts or connected through toothed gears to other types of apparatus.

While vast strides have been made in turbine progress, effort is still being made toward improvements in matters affecting economy, reliability and safety. Reference to future possibilities is interesting.

All machines are now provided with automatic stops, the main throttle valve itself being arranged to be operated automatically by the stop governor. The advantage of such an arrangement is that the valve must necessarily be maintained tight; second, it must be operated every time the turbine is started or stopped; and third, the valve may be partially closed even while the turbine is operating, so there may be assurance of no sticking in the pistons, etc. Valve seats of monel metal appear to be most capable of resisting the erosive action of steam.

More attention is being given to the exhaust passages of turbines, that the steam may leave the turbine without eddies in the exhaust chamber. The hot and cold spots with the turbine operating under light load operation, and particularly on a change of vacuum, doubtless inducing considerable temperature strains of older designs have been eliminated. Some later large machines are projected with "stream line exhausts," the steam being divided up, as it leaves the last row of blades, into a number of easy curved passages leading to the exhaust opening.

With high-speed machines, the exhaust passages have greater physical dimensions than anything else about the machine, the turbine almost appearing to be all exhaust chamber so any further reduction in diameter in the inherent turbine parts, will not materially affect the dimensions of the whole turbine.

It is plain that with turbines of large size, which deliver to the switchboard 76 to 80% of the theoretical energy available from the steam expanding between the limits specified, further improvements in the turbine itself will not materially raise this efficiency, and that further improvement in central-station economies must be looked to from causes other than the steam turbine. This is a subject of the greatest importance in view of the rapidly increasing cost of fuel and justifies considerably more capital expenditure for economizers and other plant apparatus which will reduce fuel cost.

Attention at the present time is being directed to employing higher boiler pressures, viz., pressures as high as 600 lb. Today 200-lb. pressure, 200° F. superheat is regarded as a more or less every day operating condition for large plants. Steam generated at 600-lb. pressure, having exactly the same heat content as that contained in 200-lb. pressure and 200° F. superheat, will have a superheat of approximately 128° F. This expanded to 29 in. of vacuum is theoretically capable of giving 13% more energy than when generated at 200 lb. Doubtless, when operating under these conditions, the turbine will be of lower efficiency. The high pressure element will be less efficient on account of the great density and the small volume of steam, and, on the other hand, the low-pressure elements will be less efficient because of the great amount of water precipitated by the steam expansion from the high pressure, introducing a brake in the turbine. However, it is reasonable to suppose that the turbine will avail itself of at least 50% of this 13% possible, producing a net saving of 6 or 7%.

Another source of improvement of performance in large multiple-cylinder machines may be obtained by intermediate reheating, the steam expanding from a high pressure and superheat through a high-pressure element to a pressure of, say, 40 lb. absolute, where nearly all the superheat has disappeared; the steam then being passed through a separately fired superheater and raised to approximately its original temperature, thus giving a nearly dry cycle to the whole steam expansion. The addition of an intermediate reheater to such an installation would be expected to secure an improvement in total B.t.u. supplied, of 3%. Until lately, however, the capital expense involved would hardly have been warranted.

Much more than formerly, attention is being given to the subject of feed-water heating and means are available for providing a heat balance between the feed-water heating system and the main turbine unit, valves being provided which will take steam from the turbine whenever there is a deficiency of auxiliary exhaust steam for heating feed-water and take steam from the heating system when the feed-water heater is incapable of condensing all of the exhaust steam from the auxiliaries. Valves are also available which, when the conditions demand, will take steam from a higher pressure stage of the turbine in one case and admit steam to a lower stage in the other.

A heat balance system has been proposed employing electric motors for driving the auxiliary machines, and these in turn operated by a special generating unit, the generator being driven both by a non-condensing steam turbine and an electric motor operated from the main busbars, the flow of steam to the turbine being controlled by the pressure in the exhaust and, hence, by the needs of the feed-water heater. At times of excessive demands for feed-water heating, the motor may give energy to the system and conversely when there is a small demand for steam for heating feed-water, the energy for driving the auxiliaries will, in part, come from the main units. The auxiliaries, being motor-driven, have the advantage of reducing the general dirtiness, heat and overcrowding to be found in the basements of many power plants on account of the steam and exhaust piping of the many small turbines. The general prejudice against electric motors for the other auxiliaries would seem to be giving way in view of greater ruggedness of electric motors and the safety of their circuits. The heat energy actually required to operate the auxiliaries with such a system would be far less on account of the better performance of the large turbine unit as compared with the number of small non-condensing auxiliary turbines, in spite of the electrical losses involved.

Further economy may be expected by making more extended use of the economizer. Until lately it has been considered difficult to operate economizers successfully if the feed-water is admitted to them at temperature much below 200°, because of corrosion of the surfaces and the condensation of tarry compounds from the fuel. It is probable that in the future economizers will operate well with the water entering them at 120° or thereabouts, the water being heated to this temperature by a fewer number of steam-driven auxiliaries or by the employment of electrically-driven auxiliaries entirely and bleeding the main turbine at a stage where the pressure is commensurate with that temperature.

The present time is a very important period in the development of the steam turbine. A large number of big units have been built ranging in size from 25,000 to 60,000 kw. Those built by the General Electric Co. are of the impulse type, those by the Westinghouse Co. entirely of the reaction type, and sometimes a combination of both types, where the complete expansion is carried out in a single cylinder. Of the Westinghouse machines, the increased reliability obtained by dividing the steam expansion in separate cylinder structures is recognized. Some have been arranged with the high and low-pressure cylinders arranged tandem fashion, driving a single generator. Others are arranged "cross compound," each turbine element driving a separate generator. The very largest sizes are of the three element design, comprising one high-pressure turbine, with a low pressure turbine on either side, each of the three elements having its separate generator.

Many such units are now in operation, and within another year many more will be in service. Some of them will be tested for steam efficiency. All of them will give evidence as to their reliability of operation and accessibility for inspection and repairs. The multicylinder turbine certainly seems to have much to commend it if there is anything in the thought that with increase in the capacity of the prime mover there should be a corresponding increase in reliability. These very large units, if built in a single cylinder structure, impose grave problems of design for as the structure becomes larger the more likley it is to change shape under the varying temperatures within its walls. Also the hazard is introduced of using higher grade materials to deal with higher stresses with all the uncertainty which that question involves in the actual securing and testing of such materials without absolute knowledge that the quality of the test specimen will be secured approximately in the finished piece, and there is a certain hesitancy in doing this.

We then have the increasingly imminent question of dealing with higher steam temperatures which does not make the design of turbines any easier as is well proven in several recent instances. So if we take advantage of the fact that in size alone resides an ability to achieve higher efficiency, then it would seem that the uncertainties of design and construction as regards heat stresses, as well as centrifugal stresses, can best be removed by introducing no new questions. Let us have the high efficiency that comes with large size as being within well-tried practice, dealing with no special materials, avoiding widely differing temperatures within the same structure, keeping the high temperatures within the relatively small high pressure element, and be ready, also, for the still higher temperatures of the future. The multicylinder arrangement occupies more room, measured in the width of the unit, but less in length; however, the turbine room space in this respect is not a problem in most stations. They have the advantage, previously pointed out, that the turbine elements permit of being operated separately in the event of derangement of either one of them. Automatic apparatus is provided when demanded for any two of the three turbine elements continuing to carry load should the one be taken out of service, either by the opening of the circuit-breaker or by tripping the emergency stop.

The compound unit costs more money, but not prohibitively more, if the construction behind its adoption is justified by experience. In view of the present power house costs, there would seem to be no economic need of reducing the cost of the turbine units below the amount required to make them as nearly perfect as possible. It is hoped that the time is not far distant when the turbine designer will not have to initiate quite so much as he has in the past; that on the operating side the engineers will test their turbines more generally, will know precisely what results they give in steam consumption, and will take a stronger position respecting the mechanical features of design, details of operating convenience, etc., much as they used to when they dealt with the subject of Corliss engines, and recognize and give consideration to better detail design of the turbine itself and its appurtenances.

The progress in the construction of turbines has not been to reduce intrinsic cost. The increased reliability, while sometimes secured by more skillful design, and at even a reduction of cost, generally, however, involves a greater cost. The more difficult operating conditions, higher pressure, superheat and vacuum, each involves greater expense. The higher vacuum calls for larger low-pressure blade areas, as well as an increased number of turbine elements. The higher pressures and superheat both involve more turbine elements, and also preclude the use of cast iron for the high pressure portions, adding materially to the cost of the units. Competition calling for the highest performance has brought about the employment of higher design coefficients which introduce still another element of increased cost. The increase in rotational speed for a given size machine is about the only item besides improved manufacturing processes that have enabled manufacturing costs to be reduced, and for alternating-current apparatus speeds now have reached their limit for large units.

The future development of the steam turbine will be along lines of greater reliability, greater safety and increased economy.

*The Electrical Review.

Photos by Underwood & Underwood

Some of the intricate machinery for paying out and recovering submarine cables

Splicing a broken cable is an operation requiring much skill and care

Maintaining Ocean Telegraph Cables

And Their Survival in Competition with Wireless Systems

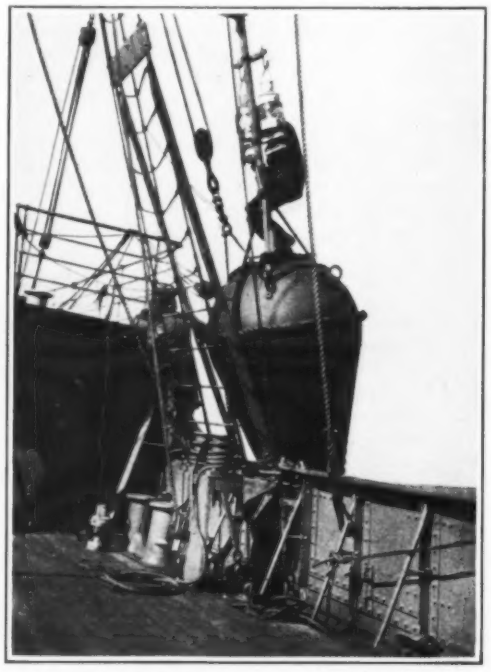
THE recent confiscation and assumption of the operation of all means of intercontinental communication by the government has raised in some quarters the question, how long ocean cables will survive in competition with the wireless system? It is fully appreciated that the cable is practically immune to weather conditions, and also to the influence of exterior forces, and consequently it is the most reliable means of communication between distant continents and but little liable to interruption either from natural causes, or intentional interference. Moreover the privacy of communication over the cable is practically assured, whereas it is by no means difficult for interested outside parties to intercept messages by the radio systems as at present developed.

The objections to the submarine cable are the expense of installation and of maintenance, both of which are very considerable and uncertain. In preparation for laying a cable line as careful a survey of the bottom of the ocean as possible must be made, and as this survey can only be done by soundings, it can be readily appreciated that there is always present a very considerable element of uncertainty. The character of the material composing the bottom may be of such a nature as to be decidedly injurious to the cable; and then again, an undiscovered fissure of any considerable depth results in a loop in the cable that may easily result in a break from its own weight in the course of time. As the soundings average very considerable depths, and as they must be made, often, in a rough sea, it is not practical to make them very close together, several miles often intervening between individual soundings. It is apparent therefore that the profile and record of conditions of the bottom of the ocean along the proposed line are more or less approximate, although experienced engineers, keenly alive to slight indications, are able to arrive at very accurate and satisfactory results. All of this however costs a great deal of money, as it is expensive to operate a ship of the size necessary to carry out this kind of investigation, and the work progresses but slowly.

After the survey has been concluded, and a satisfactory route has been determined upon, comes the actual laying down of the cable, which is also a slow and enormously expensive operation, particularly as the cable itself costs a great deal of money. According to reports there are between 290,000 and 300,000 miles of ocean cable now in operation, and the capital involved in putting this vast mileage into working order may be imagined.

After the cable has been successfully laid down it is, like every other human structure, liable to all sorts of misfortunes, due to unavoidable defects in original construction, unforeseen happenings in the depths, either from the action of chemicals in the material in which it rests, salts in the water, cutting on rocks or the operations of the denizens of the deep; and when a cable fails from any one of numerous vicissitudes to which its delicate constitution is subject, it is often an exceedingly costly bit of work to re-establish communication.

The accompanying illustrations show some of the incidents connected with the repair of an ocean telegraph cable. When communication through the cable ceases, careful tests are made with delicate instruments by means of which the approximate position of the fault is located, and the repair ship is at once despatched to the spot. Every company operating any considerable mileage of ocean cable must own at least one of these repair ships, which are also employed to lay new lines when required; and as these ships are of no mean size, and must be kept constantly in commission, ready for instant service, a very considerable expense is involved, not to speak of the greatly increased costs when in active service. An idea of these expenses may be derived from one incident, which, although it may be considered exceptional, is always possible. Years ago, on the occasion of a break in one



Preparing a large buoy to mark the location of a cable end

of the Atlantic cables, it required several weeks' work to pick up and restore connections, at a cost of $400,000.

When the cable ship arrives at the estimated point of trouble a grapnel attached to a long steel rope is lowered, which is towed back and forth across the line of the cable until it is securely hooked, so it can be drawn up to the surface. If the ocean bottom at the location is comparatively smooth, and of soft material, this may often be accomplished in a few hours; but on a rocky bottom the operation is much more difficult and protracted, as the grapnel catches on the rough stones and it is hard to tell when the cable itself is actually hooked. For this operation many different kinds of grapnels have been devised, with spring hooks and other arrangements intended to release when a rock is engaged, or the strain on the towing rope becomes too great. The difficulty of this deep sea fishing may be appreciated when it is known in what great depths some of the cable lines are laid. In the Pacific Ocean at one point on a cable line a depth of over 26,000 feet was recorded; but where possible such conditions are avoided as a rule. Sometimes, in making a submarine survey, lofty mountain peaks are encountered with almost bottomless valleys between, and if a telegraph cable were to be laid over such an eminence, great loops of cable would be formed in the adjoining valleys, which would be liable to break of their own weight. In such cases it is usually possible to find more suitable bottom by slightly diverting the line.

Many improvements have been made in the construction of ocean cables since the first lines were laid, over sixty years ago, and now much better protection is afforded in insulation, strength and resistance to marine borers and the action of chemicals in the slimes of the bottom and the water, so that defects are now of much rarer occurrence than formerly; but there is probably no such thing as an indestructible cable, and consequently a heavy maintenance item will always continue to figure in the expenses of the cable companies. On the other hand, radio telegraphy, and later the telephonic systems, are comparatively new enterprises, and their development is really in an initiative stage. Great improvements are, however, constantly being made, and it may be confidently expected that at a no very distant time most of the present troubles due to atmospheric conditions will be largely overcome. The privacy of wireless communication appears still to be a most serious problem, and until this can be practically assured the submarine cable will undoubtedly hold its own as a means of commercial and diplomatic communication.

Storing Heat

A NOVEL electric heating system has been installed at a school in Baden, the arrangements being such as to enable the heat to be stored up during the night, when the generating station is lightly loaded, and to be used for heating purposes in the daytime, says the *Electrical Review*. The installation utilizes the existing hot-water system and radiators. A water container of about 15,000 litres capacity, surrounded with an effective heat insulation, is used for heating the water. Inside this container electric resistances are built that raise the temperature of the water to 110 degrees Cent. during the night. The hot water can be circulated through the system of pipes, its speed being regulated by a valve. The quantity of water in the reservoir is sufficient to keep up the circulation of hot water all day long without switching on the current. Provision against over-heating is afforded by a thermostat. The supply is taken from a 2,000-volt network, and the voltage is transformed down to 220 volts. The total power taken is 100 to 120 kilowatts. The advantage of the system consists in storing heat at a time when the energy is cheap, and thus using a portion of the water power that is usually run to waste at night time.

Aviation and the War*

By C. F. Lee
Commanding Officer, British Aviation Mission

I SHOULD much prefer to stand here and answer a few direct questions rather than to try to give you miscellaneous information on subjects connected with aviation. But there are representatives here of so many different sciences, men who are in the habit of asking and answering questions on such a variety of topics, that it is probably better that I do not attempt to answer any scientific questions at all on the theory of aviation, especially as my scientific knowledge of it is nil.

Not everyone realizes how long a time it takes to make a service flyer. The average period, from the time that the pupil is brought to the cadet schools of the Flying Corps to the time he is ready to go over-seas and fly over the lines, is about seven months. That is a very considerable length of time, especially in these days of intensive training and preparation, yet the actual training in flying is one of the simplest items. The principal factor to consider in teaching flying in war time is whether it is worth while to spend the necessary time on a pupil. If a country is at peace and there are plenty of machines available, it may pay to stick to a man who will undoubtedly make a flyer sooner or later, for anyone can fly if sufficient time be given to his instruction. But in times of war when, as at the present time, we have neither a surplus of machines available for flying nor the extra time to spend in training, it is not a practical thing to do. The hard, specialized training which everybody has to come to sooner or later is not only important, but absolutely essential.

Much has been said about "dangerous stunts," frequently with the implication that these are spectacular performances which thrill the spectators but are needlessly risky, and I should like to devote a few words to this matter.

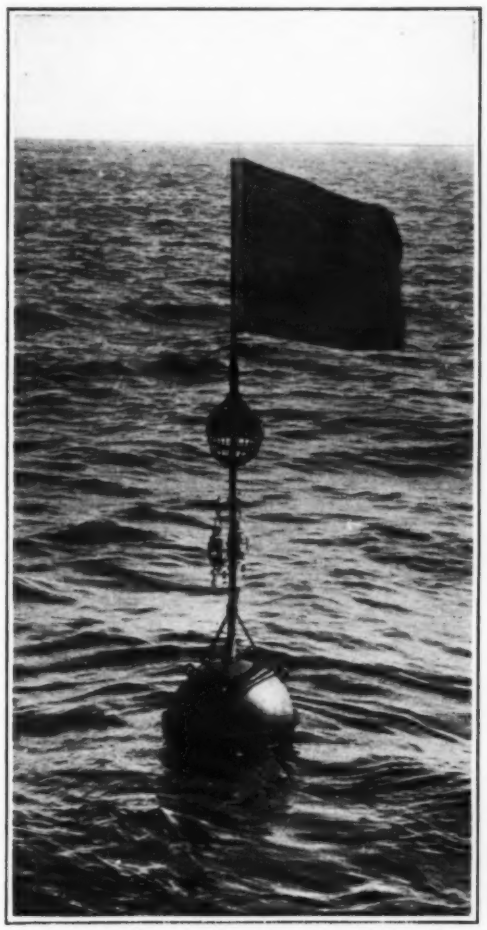
It is quite true that some lives were lost in the earlier days in instructing pupils in what we call "stunting," but it is quite useless to send a man over-seas if he is unable to "stunt." In individual fighting, unless the flyer can really do things better than the German, he is not going to come out alive. For instance, when one machine meets another, each speeds up and goes through every kind of maneuver to get into a good position so as to be able to "get" his opponent. The man who is going to come out alive is the one who can outdo his opponent in flying. It is not a question of "getting away from the German." It is not a matter of getting away at all, but of getting into a good position so that you can down him. He is going to do the same thing as you are, and unless you are able to outdo him in his maneuvers you are going to come out beaten; and unless you are trained to do real stunts (which are really not at all dangerous), you are not going to be able to down him. The danger is not in "stunting;" the danger is in not being able to "stunt."

If a flyer goes over-seas and cannot do these things, then his life isn't worth a "scrap of paper." If he can do these things, and if the time comes when he is absolutely match to match with his opponent, the man who will kill his opponent is the one who can turn his machine about at will and get out of a difficult position. Getting out of the difficult position saves his life, but that is not all; the real problem is to get into a good position so that he can down the enemy, and the downing of the Boche is the thing that every flyer is out for. He is there not to get away; he is there to kill his opponent.

To succeed, the flyer must be taught properly. It may cost one or two lives on this side of the water, but if the men are taught thoroughly it will mean the ending of these casualties on the other side. What is more important, if the flyer does not know how to "stunt," it will not only mean the death of the pilot himself, which is relatively not so important in view of the fact that so many thousands of men have been killed in this war, but it may result disastrously to a great number of men on the ground. When the man in the air goes down, there may be batteries depending on him for spotting our own fire and the enemy's artillery; there may be infantry regiments waiting to know where the Germans are; and there may be whole divisions waiting for certain information. It is thus absolutely criminal to send a pilot to the front who does not know how to fly, and the only way to make him capable is to teach him to stunt. It is now taught at all the flying schools.

The teaching of stunting is not difficult, but we must have pupils who have a certain amount of knowledge and skill. I will give you one or two instances which we had in the beginning of the war. We were very hard pressed for apparatus and very hard up for machines by the end of 1915. A lot of pilots were sent over-seas after they had been given the best training that the short time would allow, but there were many casualties. Some of them were due to the fact that some of these fellows could not really "stunt" their machines. The Boche would get "on their tail" and they would put their nose down. If the man in the disadvantageous position puts his nose down, the pilot on his tail can do the same and get him very easily. Now, the fellow who can stunt will do some fast climbing, turn, and maneuver himself into a better position from which to attack his opponent, while the fellow who cannot stunt will put his nose down and try to get away and will find himself an easy mark for the enemy. This was very noticeable with raw German flyers.

I want to make it very plain that there is no danger whatever in stunting, and I could show you that with proper training a pupil can be taught to stunt in twenty-five hours. The only danger is in doing it too near the ground, but at 2,000 feet there is not a single position that the machine cannot be put into with safety.



A buoy marking a cable end, as it appears in the water. It is provided with a large flag, a cage and lamps to make it easily visible

The evolution of the machines themselves is very interesting. At the beginning of the war we had only about four small squadrons, of 12 machines each. They consisted of what we now call very old machines. There were some Farman machines, some 2. A and B's, and one or two Bleriots, which at that time were considered very speedy machines. All those machines are now considered too slow even for training. In those days they used to fly under 3,000 feet and used to come back with a tremendous lot of bullet holes in their machines, but there were not many casualties. As the war went on, with time and experience the machines gradually were improved, until at the present time we have scout machines that fly 135 miles an hour, machines that will climb 15,000 feet in less than fifteen minutes.

That is the evolution that has been forced on France and England. It is a matter of life and death to the Allies to keep just a little better than the German. But it is very hard to get very much better than he. In practically every case a machine is obsolescent from the time that it appears on a production basis at the front. So it is one huge race to get a machine with a little more maneuverability, a little more climbing ability, and a little more speed. Your defense is not the bullet-proof seat you are sitting in; the only defense you have is the maneuverability of your machine.

To return to the training. When the pupils come to the ground schools they get a certain amount of ground training. They are told what the machine can do, and the detailed operations that are performed by the various parts. They are also given the ordinary subjects connected with drill and military life. After six or eight weeks in training, when they have become soldiers to a certain extent and have acquired a certain amount of discipline, they are drafted to a school of flying.

At this school of flying, according to their temperament, according to how they fly, according to age, and according to their all around knowledge, they are assigned to one of three branches; first, the single-seater scout; second, the artillery-observation squadrons; or, third, the bombing machines for both day and night bombing.

All these subjects are highly specialized at the present time. It is absolutely impossible for a pilot to be an expert in all three subjects. He may be an excellent flyer in a heavy machine but he may fail as a gunner; another pilot may be extremely good in the scouts. All these things require special knowledge and special tactics for teaching them. The pilot in the single seater must be an expert gunner. He must know his gun absolutely thoroughly, but if he can't shoot straight he may as well go home. Some machines have three or four guns. If a gun goes wrong, the pilot must be able to locate the trouble and correct it. He must go through various courses of training, including "stunting" courses, and until he has completed these he is not allowed to go over-seas.

Furthermore, before he goes over-seas he has to be absolutely proficient in what is called formation flying. In former days the machines went out one, two, or three at a time. Nowadays it is of no use to go over alone or in pairs. The machines now fly in sixes, eights, twelves, sixteens, and twenty-fours. They fly together, bunched up and well packed in. If the formation is well packed in no Boche will attempt to touch it. But if one of the pilots drops out of the formation, if his engine goes wrong and his revolutions start dropping and he starts losing height, then the enemy is after him. They wait their time until he is well out of his formation and then his only safeguard is to stunt.

A friend of mine (now Colonel), Jack Scott, used to go out "Hun hunting" by himself. He once was out beyond the lines looking at his own squadron, when a squadron of Boches came between him and his own lines. The only thing he could do was to stunt, and although he got bullets all through his machine, his gun was hit, he had three holes through the seat, and a lot of holes through other parts of his machine, he got away all right. But he said he got so tired of flying around and around that he was almost ready to give up, when one of the enemy happened to come in line, and Scott fired when he saw him on his sights. The Boche went spinning to the ground. That little accident heartened him so that he revived and got away.

There was another fellow, Bishop, who was of the same sort. He went out scouting alone and saw five enemy machines just getting ready to leave their aerodrome. He flew right down close on top of them and crashed two machines before they left the ground. He then went for the third machine and sent that crashing to the earth. But things were then getting too hot for him so he climbed two thousand feet, where he finally got the fourth one. Then to show his indepnedence he went after the fifth. He got the Victoria Cross for that.

Artillery machines are quite another matter. They have a very hard job and a very interesting one, and it is a job that requires lots of courage because they have to stay in the same place over the batteries and spot the other batteries' fire. They have to keep their eyes on the land, and on a cloudy day the enemy sometimes creeps up on them through the clouds. Generally speaking these men are a little older and are chosen because they have the temperament and are a little more suited to staying over one place and seeing the job out. It is not very pleasant for the men who are accustomed to scouting to have to fly over a certain area and see the same place every day. The artillery nowadays is practically dependent on wireless and aeroplanes for spotting. The total number of aeroplanes you can get now in a definite area is dependent on the wireless you can get into that area without being "jammed," and not on the total number of machines available.

Coupled with the work with the artillery, these aeroplanes also have duties to perform with the infantry, such as contact patrols.

*Report of a lecture given before the Washington Academy of Sciences from the Journal of the Academy.

Definition of Valency*

A Discussion of an Important Principle of Chemistry

By F. H. Loring

THE atoms of different elements, or the atoms of the same elements, chemically unite with one another to form bodies of varying stability against decomposition by heat, exception being made (1) to the inactive gases which do not combine at all, and (2) to certain atoms lacking in mutual affinity, or being too mutually unstable to co-exist at ordinary temperatures as definite molecular compounds. In respect of (2) fluorine and oxygen would be good examples, since no compounds of these two elements solely have been produced. Fluorine unites more or less vigorously with every element except oxygen, chlorine, nitrogen, and, of course, those of the helium family.

The atoms which do combine, combine to form groups known as molecules. (The term *group* is herein used to denote atomic combinations involving two or more atoms.) In solids it cannot be assumed that the groups are definitely defined as is the case with regard to gases. The selective property asserts itself more diffusely in solids than in gases, so that the latter afford numerous examples in which the difficulties are not fully satisfied; whereas, in the former, the affinities may be more scattered and, indeed, generally fully satisfied; consequently, this action may help to bind the ideal groups or molecules together as a whole. "Even when . . . the combining possibilities of an atom are exhausted, it possesses a particular kind of affinity, which enables it to form molecular complexes." In other words, molecules are known to associate.

Molecules which, for example, are normally diatomic at ordinary temperatures may become monatomic at high temperatures, permanent combination being then prevented owing to the extreme activity of the gas-particles; Br_2 and I_2 may be taken as examples. The gas-molecules are, however, definite entities (the most direct proof of the existence of atoms and molecules is to be found in Sir J. J. Thomson's positive ray experiments), and by determining the combining proportions of respective atoms in bulk, and the density of the resulting substance in the vapor state, it has become possible to assign to the atoms the property of selecting or receiving to themselves certain numbers of other atoms, but this selective or receptive power or capacity does not represent an attractive force or affinity which corresponds in magnitude to the number of atoms attracted or united. For example, a man may have two hands and be able to select two objects or have the power of joining hands with two other men of one hand each, or he may join hands with one man with two hands. The two-handed man, in fact, has a selecting capacity of *two*, but his affinity or hand-gripping power depends upon an energy consideration which depends upon the other man's grip as well, so that the stability of strength of union is independent of the number of hands. The number of hands, however, represents the valence or valency.

The hand illustration of valency is an exceedingly useful one, and there are cases which point to the possibility of the valencies, under certain conditions, being self-satisfied, as if, for example, the two-handed man had interlocked his own hands, thus by analogy implying that two valencies of the atom are rendered inactive towards other atoms.

Some atoms combine individually with eight other atoms (*e. g.*, osmium fluoride, OsF_8), as if the atom had *eight* hands, to continue the simile, this being the maximum valency, while *one* is the minimum in other cases. Many atoms appear to bring into requisition more hands, as it were, when combining with the atoms of one particular kind of elementary substances as distinct from another, so that such atoms exercise a *variable* valency. It might appear that the reserve valencies implied in the foregoing statements are internally or self-satisfied, as stated above, until called into action, but much uncertainty prevails regarding such matters. Some atoms have apparently only one unit valency and answer to the one-handed man. The inactive gases answer to a man without any hands at all, unless it be assumed that certain valencies are internally satisfied and that they cannot be called into action.

It should be noted that the one-handed man, or the man without any free hands at all, could when closely associated with other men, exercise certain interlocking powers if the legs were brought into proper action for this purpose. Hydrogen, for example, which is supposed to be only univalent in the solid state (as in other states) may exercise certain subsidiary affinities or interlocking powers which might account for its cohesion. Frozen liquid hydrogen is a rigid substance like frozen water, and if the affinities are to some extent diffuse in the latter (see below) it would be expected that they would be diffuse in the former. This means the unity valency values may not represent a complete statement of fact when taken as implying that the valency is fully satisfied in the molecule, otherwise molecules of hydrogen, to keep to the one example, would behave like dust below the freezing temperature of this element; *but*, cohesion and valency are not generally regarded as the same phenomenon, and it is going beyond the doctrine of valency to discuss such matters. Before leaving this extension of the subject a few further observations may be of suggestive interest.

The inactive gases are liquefiable and solidifiable, and in these states they behave in a general way like ordinary liquids and solids, but they do not form chemical compounds with other elements, and it is doubtful whether they feebly combine or associate among themselves to form molecular complexes even of the simplest type. For instance, the atoms of liquid argon do not appear to associate. The fact that they have no valency does not mean that they have no affinities at all, otherwise there would be no cohesion. Water and hydrogen afford parallel examples to the above in some respects, as H_2O and H_2 may be regarded as molecules practically of zero valency, yet molecular complexes or association phenomenon in respect of the former are known.

Radio-active phenomena indicate that possibly helium is a common constituent of all atoms except hydrogen, in which case its combination must be of a superior order to anything coming within the range of controllable phenomenon known as chemical action, but like the molecule in crystals (see below) the definite individuality of such a fundamental helium atom or unit taken as a sub-atom may be lost, or merged into a larger whole. In this case a deep-seated type of valency may exist accompanied with an affinity far superior to anything exhibited in chemical phenomena, just as ordinary valency is in a sense more fundamental and definite than that which is connected with the formation of molecular complexes. The gradation is fairly complete as the last-named phenomenon shades off into cohesion. It will be seen that this line of reasoning leads to four physico-chemical steps, namely:

1. Helium atoms as sub-atomic units, involving a superior type of valency and affinity. A further subdivision into similar hydrogen units has been foreshadowed as a possibility, in which case a similar antecedent step to this one might be expected.

2. Atomic combinations under control of the chemist, involving ordinary valency, but with affinities which are not co-related to the valency values.

3. Molecular complexes, involving a sort of residual or excess valency which tends to become diffuse.

4. Cohesion, involving a still more remote type of valency which being wholly diffuse is more of the nature of an affinity pure and simple, and, indeed, in this case the idea of *valency* may be entirely eliminated.

It must be admitted that these statements are to some extent speculative, but such ideas, though of necessity very general, may help to clear up doubtful points which obscure the interpretation of valency proper. The quotations given at the conclusion of this article may be of interest in this connection.

As stated above, the valencies exercised in solids are largely conjecture, but there is sufficient evidence in many cases to show that the values assigned to the atoms represent characteristic properties. For instance, hydrogen and oxygen combine to form water in the atomic proportion n (HH): nO, and in the gaseous state the molecule H_2O is known. Oxygen in this case is said to be divalent (or bivalent) and hydrogen univalent (or monovalent). In the liquid or solid states molecular complexes are said to be formed, these being represented as $(H_2O)n$. Probably in such cases the valencies are to some extent diffuse, but uncertainty exists with regard to the precise dispositfon of the valencies when considering the manner of direction in which they may be supposed to operate. In solids the valencies may extend to atoms of adjoining "molecules," so that definite molecules in solids hre considered by some as purely an ideal concept, their existence becoming definite, however, when, by the application of heat, the kinetic energy imparted to the atoms causes them to move about in groups. When the heat is intense enough the groups themselves break up into single atoms.

In crystals, X-ray analysis has shown that the constitutional formulæ of the chemist do not exist as such, the molecular individuality then being more or less lost, and this agrees with the foregoing statement with regard to solids in general.

The degree of stability of a compound depends upon its composition or character apart from the valencies of its respective atoms. It sometimes happens that particularly stable compounds have other than the normal valencies exercised in the molecule; or, on the other hand, the normal valencies are not fully satisfied. Nitric oxide, NO, is particularly stable at moderately high temperatures, and it seems probable that both nitrogen and oxygen are quadrivalent (or tetravalent) in this case. It might be supposed that the strength of the atomic union *i. e.*, the resistance of the compound to decomposition when its temperature is raised, may be due to the number of valencies exercised, and therefore a connection between valence and degree of affinity at once suggests itself; but there are so many exceptions in this respect that no law has been established.

It will be seen that valency on the whole is a somewhat elastic conception. When an atom is defined as having a certain maximum valency, the value so assigned to the atom is only characteristic when entering into combination with certain other atoms. Similarly, the minimum valency is only characteristic in rsepect of other particular combinations. Some atoms have no variable valency, in which case the maximum valency and minimum valency coincide. There are, however, combining regularities which are sufficiently well defined to enable one to classify the elements into groups and at the same time to assign to their respective atoms certain valency values, so that combinations may be predicted and chemical behavior elucidated.

The regularities of the valency values may be expressed in tabular form thus:

	H.	He.	Li.	Be.	B.	C.	N.	O.	F.	
Max. val.	1	0	1	2	3	4	5	4	3	&c.
Min. val.	1	0	1	2	3	4?	3	2	1	

The valency (or valence) of an atom is its selective or receptive capacity for one or more atoms (8 seem to be the limit) when combination takes place; and it is either expressed in terms of the *number* of hydrogen atoms (1 to 4) which it combines with or displaces, or in terms of the *number* of chlorine or fluorine atoms (1 to 8) which it combines with or displaces, under conditions that preclude the probability of each halogen atom itself functioning in a higher combining capacity than unity with respect to the atom whose valency is thus being defined.

There are cases in which the valency may be deduced by combinations involving other atoms than those cited as standards; but this definition affords a basis for establishing such other standards. For example, oxygen (O) usually functions as a divalent atom, but under certain circumstances it appears to be quadrivalent.

The following quotations bearing upon the subject under elucidation should be of particular interest:

1. A. Smith, "Introduction to Inorganic Chemistry," 1918, 3rd. Ed.

2. Mellor, "Modern Inorganic Chemistry," 1912.

3. J. N. Friend, "Theory of Valency," 1909, 1st Ed.

4. J. Perrin, "Atoms" (translation), 1916.

5. *Science Abstracts*, Section A (Physics).

1. "It is only in the chemistry of carbon that the prejudice in favor of a single valence [4] still persists. All chemists admit that in carbon monoxide, CO, the carbon is bivalent. But not all chemists admit that it is also bivalent in fulminic acid, H–O—N=C, and in the isonitriles R–N=C. For the unsaturated compounds, like ethylene C_2H_4, and acetylene C_2H_2, all chemists write the formulæ H_2=C=C=H_2 and H—C≡C—H, although there is at present no experimental evidence that the formulæ H_2=C—C=H_2 and H—C—C—H, in which the carbon is trivalent and bivalent respectively, do not represent the fact equally well, so far at least as valence is concerned. When triphenylmethyl, $(C_6H_5)_3C$, was discovered by Gomberg it seemed as clear that in this substance one atom of carbon was

*From *The Chemical News*.

trivalent as that the copper in CuI is univalent; but violent efforts were made to avoid this obvious conclusion. For example, it was suggested that three of the valences held one C_6H_5 group each, and that the fourth valence was divided among the three groups (partial valence). But valence goes by multiples of one equivalent, and this idea involved *splitting* one valence into thirds of an equivalent. The *affinity* of the carbon atoms is doubtless all divided among the three groups, so long as no fourth group is present to share it, for affinity is not divided into any definite number of units. This is a case of unconsciously confusing valence and affinity." (P. 137.) (See "Theory of Valency," by Friend, p. 42.)

"*Is Solution a Physical or a Chemical Change?*—These phenomena are, in part, accounted for by the fact that water is not a single substance, but a mixture. It is largely composed of dihydrol, $(H_2O)_2$, with much trihydrol, $(H_2O)_3$, near to 0°, and increasing quantities of monohydrol, H_2O, at higher temperature. When *any* substance is dissolved in considerable amount of water the equilibrium among these three kinds of molecules is disturbed, and their proportions change:

$$2(H_2O)_2 \rightleftarrows 3(H_2O)_2 \rightleftarrows 6H_2O.$$

Now, equal weights of these three kinds of water occupy different volumes, and hence solution is accompanied by changes in the volume of the *water*. The same condition in water explains the point of maximum density (4°). The change from $(H^2O)^3$ to $(H_2O)_2$ which proceeds as the temperature rises from 0° to 4°, is accompanied by a *shrinkage*, because the dihydrol has the higher specific gravity. Beyond 4° the usual expansion with rising of temperature prevails. . . . Dissolving in water is therefore partly a chemical and only partly a physical process—a part of the water is always affected, and a part or all of the solute may go into combination." (P. 202.)

2. "The principle of self-saturation breaks down when applied to the nitrogen oxides, say, NIIIOII The relative density of the gas (Avogadro's hypothesis) will not let us write N_2O_3; that is, O=N—N=O. We are therefore confronted with what appears to be an odd unsaturated valency in the molecule, —N=O. Again, molybdenum forms a series of compounds with univalent chlorine or fluorine, $MoCl_2$, $MoCl_3$, $MoCl_4$, $MoCl_5$, and MoF_6, and vanadium forms VCl_2, VCl_3, VCl_4, and VCl_5. In view of facts like these it is difficult to maintain the thesis that the apparent inconsistency of the valency of an element is due to the mutual 'saturation' of pairs of valencies. Either a molecule can exist with free valencies, or Kekulé's maximum valency hypothesis breaks down when confronted with facts." (P. 71.)

3. "In nitric oxide, NO, whose molecules are single at temperature as low as −100° C., the valency of nitrogen evidently depends on that of oxygen. As we shall see in a later chapter, oxygen can function as a tetravalent atom, and in Chapter XIX. reasons are adduced to show that in nitric acid we have *the first example of tetravalent nitrogen* [N≡O]. All efforts to obtain other derivatives of tetravalent nitrogen have, up to the present, resulted in failure." (P. 82.)

4. "We have not yet put forward any suggestions as to the nature of the forces that keep the atoms grouped together within the molecule. It may be that each atom in the molecule is joined to *each* of the others by an attraction that varies according to their nature and decreases rapidly with the distance between them. But such a hypothesis leads to no verifiable conclusions and presents considerable difficulties. If all hydrogen atoms are attracted by all other hydrogen atoms, why is it that the only molecule built up of hydrogen atoms is H_2, the capacity of the hydrogen atom for combining with itself being exhausted directly two atoms become united? It appears as though each atom of hydrogen stretches out a single *hand* only. Directly this hand succeeds in gripping another hand the capacity for combination of the atom is exhausted; the hydrogen atom is therefore said to be *monovalent* (or better, univalent)." (P. 32.)

5. "*Relation of Molecular Cohesion to Surface Tension and Gravitation.* . . . A. P. Mathews (*Jour. Phys. Chem.*, Oct., 1916, xx., 554).—This paper constitutes a revision and extension of the studies already made on molecular cohesion (*Abs.*, 1914, 279). Its contents are briefly as follows: (1) A method of computing *a* of van der Waals' equation from the internal latent heat of vaporisation which seems to be free from all assumptions; (2) a proof that the values of *a* thus found are proportional to the two-thirds power of the product of the molecular weight and the number of valencies in the molecule; cohesion of a molecule depends, therefore, on the molecular weight and valency; (3) the cohesive attraction of two molecules at a unit distance apart is shown to be equal to the two-thirds power of their gravitational attraction at this distance, multiplied by the two-thirds power of the ratio of the number of valancies to the molecular weight; or, if M^2K, which is *a* for a single pair of molecules, is the cohesional attraction at a unit distance and m^2k the gravitational attraction of the two molecules at the same distance, then the following relation exists:—$M^2K = m^2k \times$ (valencies/molecular weight) 2/3. . . . " (P. 36, Jan., 1917.)

"*Cohesion* II. H. Chatley (*Phys. Soc. Proc.*, Aug. 15, 1916, xxviii., 307). . . . The outstanding difference between chemical affinity and cohesion lies in the selective character of the first. So far as the ability of valency bonds of an atom to hold a molecule is concerned this is a common feature in organic compounds; what is distinct in the selective process is the feature of 'saturation.' The case of silica is considered. (1) In each sub-molecule, SiO_2, the four valency bonds of the silicon atom are linked in pairs to two oxygen atoms, this being purely chemical. (2) The sub-molecules are linked in pairs, if Nernst's formula $(SiO_2)_2$ is correct; this is chemical in so far as it occurs in constant proportions, but is cohesive in so far as it is the linkage of molecules as distinct from atoms. (3) The silica molecules are linked to one another irrespective of quantity, but with a configuration of maximum stability (crystal) with four axes (hexagonal system). Linkage can occur without geometrical form (amorphous solid). The magnitude of the linkage forces is inferior to that of (1) and (2), but not incomparably so (cohesion). (4) If gravitation is not a particular case of cohesion there is, in addition, a small mutual attraction with no vector quantity in accordance with Newton's law. It would seem possible to deduce from the fields about different stable systems of differently charged spheres some idea as to the feasibility or otherwise of explaining cohesion on these lines." (P. 452, 1916.) In an earlier paper by the same author in the same society journal (Aug., 1915) it is stated that . . . "Kelvin was of opinion that cohesion could be explained by supposing the actual mass of substance to be concentrated into volumes quite small as compared with the whole volume. The density at such centres would be extremely high and this intense density would, he thought, so increase the force of gravity between pairs of molecules very close together as to account for cohesion without necessitating any deviation from the inverse square law. . . . This [distance between molecules] is found to be of the order **of 10^{-24}** cm., much less than the reputed diameter of an electron even! A second calculation is then made according to an inverse law of undetermined index, the Newtonian constant for gravitation being still retained. This results in making the cohesive force vary as the inverse *sixth* power." (P. 586, 1915.)

"*Results of Crystal Analysis*, IV. L. Vegard (*Phil. Mag.*, May, 1917, xxxiii., 395). . . . Hence, although it is found that the constitution of the solid state of zircon, rutile, and cassiterite should be ZrO_2SiO_2, $(TiO_2)_2$, and $(SnO_2)_2$ respectively, it cannot be concluded that these are adequate expressions for the chemical properties of the substances. The ordinary chemical constitution formula is intimately related to the idea of a molecule but in the crystalline state the idea of a molecule as an individual system has lost its significance. This fact alone goes far to explain why the chemical constitution formula ceases to express the structure of solids. The final conclusion arrived at is that the substances belonging to the zircon group—zenotime included—have in the crystalline state a structure corresponding to the formula M_2O_2. M_2O_2, which might be called the constitution formula of the solid state; this constitution formula may, however, be quite different from the chemical constitution formula of the substances, or from the constitution of the liquid, gaseous, or ionic form." (P. 531, 1917.)

The object in quoting extensively is to show that not only differences of opinion exist with regard to matters relating to valency, but that speculative studies in respect of cohesion (5, first part) probably point the way to a wider or rather a more extended view of the whole subject, while *experimental evidence*, as instanced by X-ray analysis (5, last part), is of great value.

A note of caution should be here sounded, namely, that quotations from speculative papers do not necessarily imply that they are to be regarded as anything more than an attempt to solve a difficult problem.

On the Phenomena of Fluorescence

By Desmond Geoghegan

FLUORESCENCE was the name given by Stokes to designate certain phenomena which he observed when following up the investigations in the same subject of Herschel and Brewster. Stokes noticed that under certain conditions the rays of light are capable of undergoing a change of refrangibility. Herschel and Brewster had observed that some varieties of calcium fluoride (fluorspar), and also certain other substances when in solution, appeared colorless when looked at by transmitted light, but when viewed by reflected light presented an appearance which varied with the material used, being of a bluish color in some solutions and of a greenish color in others. Stokes found that this property, which as before stated he called fluorescence (on account of it having been first observed in fluorspar), is characteristic of a large number of substances other than fluorspar; thus if by means of a lens of long focus, preferably made of quartz, a line of the sun's rays be focused on a solution of quinine sulphate, rendered more soluble by the addition of two drops of strong sulphuric acid, contained in a glass trough, a beautiful cerulean blue cone of light is formed which is much brighter on the surface and whose intensity rapidly diminishes as it penetrates the liquid.

It thus appears that fluorescence is due or is caused by the rendering visible to the eye of the ultra-violet rays. During the process of the invisible ultra-violet rays becoming visible, certain rays of the spectrum are necessarily absorbed. Thus rays of light which have passed through a sufficient thickness of a fluorescent substance lose thereby the power of exciting fluorescence when they are passed through a second layer of the same substance. As an example of this phenomena the following experiment should be performed by the reader: Half fill a test-tube with a solution of quinine sulphate or other fluorescent substance and hold the tube in the sunlight. Thus held the liquid appears brightly luminous, but it will lose this luminosity if it be dipped into a trough containing the same liquid which is so arranged that the sun's rays fall on its front. This absorption also results from a comparison of the absorption spectrum of a fluorescent substance with the appearance presented by that substance when the spectrum falls on it. When the fluorescence begins there also begins the absorption, and to a maximum of absorption corresponds a maximum of fluorescence. The phenomena is seen when a solution of quinine sulphate contained in a glass trough with parallel sides is placed in different positions in the solar spectrum. No change is observed in the upper part of the spectrum, but from about the middle of the Frauenhofer lines G and H to some distance beyond the extreme range of the violet, rays of a beautiful sky-blue color are seen to proceed. These now rendered visible ultra-violet rays also become visible when the spectrum is allowed to fall upon paper impregnated with a solution of æsculin $C_{21}H_{24}O_{13}$ (a glucoside extracted from horse chestnuts, and from the barks of other trees of the Genera *Æsculus* and *Pavia*), an alcoholic solution of stramonium, or a plate of canary glass (which is colored by means of uranium oxide). If light be allowed to fall upon paper impregnated with barium platino-manganide a beautiful green fluorescence is observed.

Again, if a few drops of a strong solution of fluorescein, $C_{20}O_5H_{12}$, in soda or NH_4OH be allowed to fall into a large beaker of water in the front of which the sunlight falls, beautiful fluorescent clouds are first produced, and upon shaking the liquid the whole vessel fluoresces with a bright green light.

This change, as with all the phenomena of fluorescence, arises from a diminution in the refrangibility of the ultra-violet rays which are ordinarily too refrangible to render them visible to the eye.—*Chemical News.*

Relative Efficiency of Motor-Fuels

In a newly published book "Die Treibmittel der Kraftfahrzeuge," by Donath and Groger (Berlin, Springer, 1917), an account is given of experiments with different motor-fuels recently carried out in Germany. The following were some of the results obtained:—

Petrol, pure	5.8	km.	per litre
Benzol, pure	7.1	"	"
1 Benzol+1 Alcohol	7.5	"	"
1 " +2 "	7.5	"	"
1 " +3 "	7.0	"	"
1 " +4 "	6.6	"	"
1 " +5 "	6.0	"	"
Alcohol, pure	5.4	"	"

—(*Teknisk Ukebald, Christiania.*)

Scene on the River Schie, near Delft, showing retaining dike

Holland Seeks a New Province

Plans for Reclaiming Great Areas from the Zuider Zee

By H. Merian Allen

HOLLAND is preparing to conquer two thousand square miles of fresh territory! The sole and sufficient difference, however, between this sturdy little state and the nations around her is that while some of them hope to do the same thing, and more, through means of war, she proposes achieving her end by the legitimate means of skill and peace. Her aim is to make solid land and a brand new province out of the great Zuyder Zee. And it is with much of the historic old doggedness that she regards undismayed both the cost, which will run into the millions of dollars, and the labor of at least fifteen years, required for carrying out the plan in its entirety.

Surrounded by internecine conflict, it is not less than inspiring to see the country of William the Silent, first and foremost methodically placing her main defences in order, and, then, through the parliament, calmly devising far-reaching expedients for domestic improvement.

The project had been advocated during three decades by influential committees among the Dutch, when, in 1913, at the opening of the States General, Queen Wilhelmina said, in the speech from the throne, that the time had come to begin realization of this daring dream. However, in less than a twelve-month, Europe was plunged into the vortex of hostilities, and for a brief time, though only a brief time, capital and labor drifted away from the enterprise into other channels.

The bill today before the law-making body of the Netherlands, though, for the moment, embracing somewhat restricted designs, yet contemplates the expenditures of about fifty millions. It provides for the inclosing of the inland ocean by constructing a dike, twenty-five miles long, running from the North Holland coast to the small island of Wierengen, and thence to Pinam, on the opposite Frisian shore. After the work of effectually hemming in the waters is completed, the process of drainage will be commenced. For this purpose are to be built four large basins or polders, through the instrumentality of which, within fifteen years, five hundred thousand acres of exceedingly fertile ground will be thrown open to cultivation. Need it be added that this amazing feat will be but one of many instances where the Dutch have reclaimed soil from the encroachments of the sea! Literally, half of the country has been "made"; since the sixteenth century, over a million acres trace their genesis in this fashion.

As the Netherlands has always largely relied upon forced inundations to check inroads of the enemy, the passing of the Zuyder Zee will mark, necessarily, a new era in Holland's internal defence system, as well as close to the eye an object of profound historic interest. The student of history cannot fail to remember how, during the memorable war with Spain for independence, the horrible siege of Leyden was terminated by entrance into the city of the patriot flotilla on billows created by cut dikes. It was argued then, as often before as since, "Better a drowned land than a lost one." Later on, in the mid-seventeenth century, Louis XIV was compelled temporarily to abandon operations there by the same uncompromising antagonist.

This Zuyder Zee is the youngest of all seas, but, if such may be truly said of any portion of the roaring main, it has grown prematurely old. Almost fathomless at first, so that the heaviest-draught vessel found

A view in Vollendam

navigation easy in any direction, it has now become quite shallow; the depth never exceeding forty feet, and, with a mean depth of only about twelve, the Zuyder proclaims its character as an interloper, at every point. Vast sand drifts from the North Sea, have formed into small islands, piled up in banks or resolved themselves into ever increasing layers at the bottom. The commercial adaptiveness of the once famous marine pathway is thus, in great measure, modified.

Originally, this enormous area was occupied by a dense forest in the midst of which was a lake, of moderate size, called Flivo by the Romans, the early rulers of the region; Pliny and Tacitus both write of it. The denizens of the great empire, ever inclined to experiment upon nature for the maintenance of strategic advantage, turned the attention of their engineers to the river Rhine, and a large portion of it was diverted into the Yssel having, at that time, an outlet in Flivo, the result was a gradual, persistent overflow of the little lake's banks. Trees and shrubbery were uprooted and the country, for miles around, became a soft marsh.

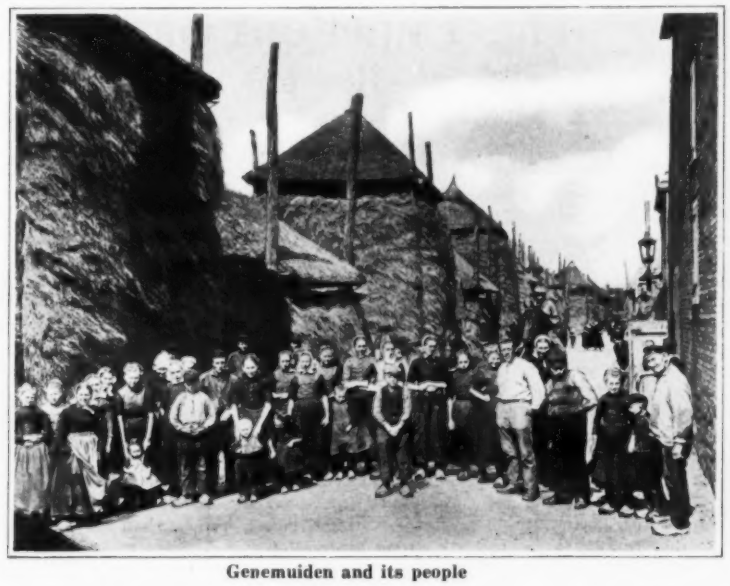
Then Neptune looked with longing eyes upon this muddy waste, claiming it for his own. About the midrle of the thirteenth century, the North Sea broke through the upper sand-dunes and swept over the land. Thousands of villages, with their inhabitants, were engulfed and destroyed. Geographical continuity was obliterated, and Holland found herself cut in two by an ocean eighty-five miles long from north to south and from ten to forty-five broad. It proved, moreover, quite as treacherously dangerous a sea as that which divided her from Britain.

Of course, it was to be presumed that everywhere on the banks of this impressive emissary of the great water god, towns should grow up, and, furthermore, that they should become rich and powerful through trade with the outer world, for was not Holland the world's carrier in those past days? Indeed, during the earlier years of Netherland's commercial supremacy, not forgetting the period following her emancipation from Spain, some of her greatest fleets were owned by these hamlets and cities. The winds and tides of the then formidable Zuyder carried them from their several ports out into the open, where they proceeded to the Mediterranean and even to the Indies.

Many such marts, by reason of changed conditions, have long been dead towns; depending through a number of passing generations largely upon romantic memories for current recognition. Among others that have retained some, at least, of the old time importance Amsterdam stands easily premier. For with its shipbuilding, diamond cutting, glass blowing, and chemicals, it is fortified against future transportation difficulties by casual connections with the North Sea.

Twenty-five miles above, in a western arm of the Zee, is Hoorn, still famous for cheese and cattle as well as ships, and surely ever to be held high in academic annals in that it was from there, in 1616, that William Schoulten sailed in the first vessel that went around South America, Cape Horn having been named by him in honor of his birthplace. Twenty-six years later, another Hoorn sailor, Abel Tasman, discovered what is now Tasmania, the seventh state of the Commonwealth of Australia, only he called it Van Diemen's Land. Still another Hoorner, Jan Peterez Corn, es-

On the Alkmaar Canal



Genemuiden and its people

tablished Dutch dominion in the East Indies. This town takes just pride, too, in remembering that it gave to brave van Tromp the navy which he used in 1652 and 1653, in breaking so many maritime lances with the English Admiral, Blake.

Some leagues to the north, where the waters of the North and Zuyder commingle and just above the site of the proposed enclosing dike, is the island of Texel off which, in the latter year, the Dutchman received a mortal wound in an engagement with the Cromwellian General, Monk.

On the bosom of the doomed sea in sight of Hoorn, occurred, in 1573, a memorable naval battle between Dirkzoon, the patriot, and the Spanish turncoat, Bossu. It was a valliant fight engaging twenty-five men of war on one side and thirty on the other, but victory rested with the Hollander and the town was saved from the horrors of a siege. Philip's Admiral was brought on shore a prisoner, received with intense aversion, and shut up for three years in what is now the picturesque Protestant Orphanage. A gold goblet, used by him during this period, is still preserved there as a curious, but not revered, relic.

Between Amsterdam and Hoorn, is the nearly defunct Edam, of but five thousand souls. Only the celebrated red cheese yet saves it from municipal death. Nevertheless, a few centuries ago, this village was a power, with a striving population nearly six times its present one, a single one of its richest burghers possessing over nine hundred ships. It was here that one more victorious fleet was constructed; that of the daring De Ruyter, with which, in 1667, he sailed up the Medway, as far as Chatham destroying all English craft in sight.

Towards the south shows Naarden, mediaevel in appearance with its surrounding moats and fortifications. In the great war, this was the scene of most frightful and inhuman carnage at the hands of the Spaniard, Don Frederic. Not far away lies Helversum, the Chislehurst of Holland, for in this delightful suburb amid green fields, spreading shade trees and bracing sea breezes, wealthy business men have erected their summer homes.

Zaandam is so close to Amsterdam that there is no wonder it is reputed one of the gayest places in Dutchland. It has more windmills, too, than even Don Quixote, in the wildest flights of his disordered imagination, ever dreamed of. This town is still an important factor in Holland's commerce, having a large number of saw mills as well as paper, glue, tobacco and dye factories. It is interesting to reflect that Peter the Great learned shipbuilding there.

In ancient times, this country, enclosed by the North and Zuyder seas, was known as Western Frisnia, and Medenblik, a few miles north of Hoorn, is distinguished as having been the residence of primitive kings of all Frisnia, among whom was that frequent subject of song and fable, Radbod. When Pepin conquered the country, this monarch was almost induced to leave his heathen gods and embrace Christianity. The story goes, however, that while the baptismal ceremony was in progress and when one royal foot had actually touched the water, hideous doubts assailed him. "Where," he asked the officiating bishop, "are the noble kings, my ancestors, who were not offered, like myself, the inestimable privilege of baptism?"

"Doubtless in hell" replied the blunt prelate.

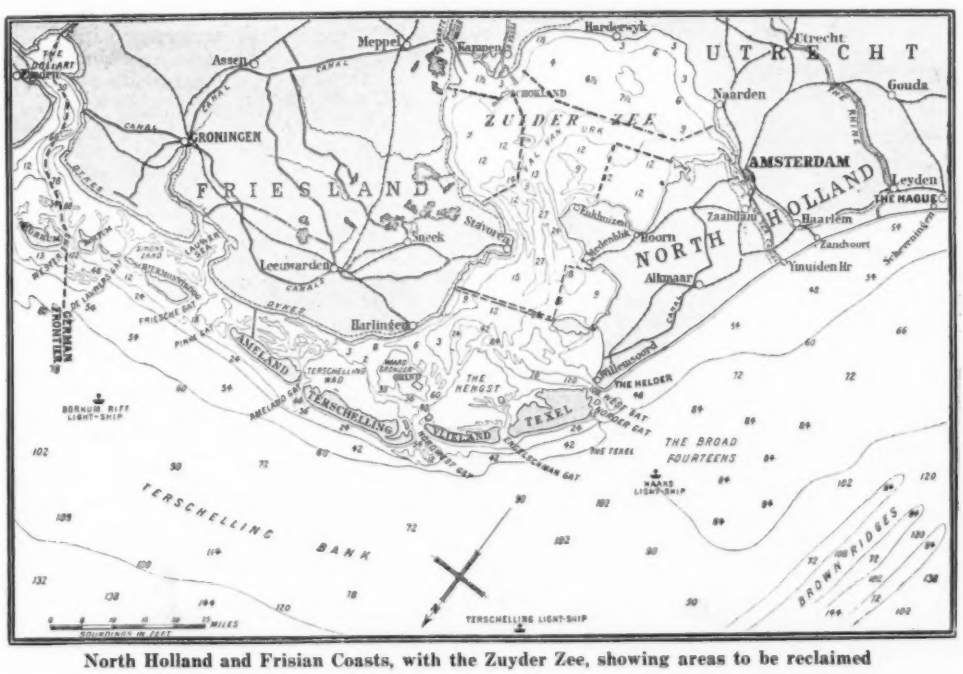
"Oh! If that is so," quickly quoth Radbod, withdrawing, "I think it would be better did I join them rather than go alone to Paradise."

At the extreme top of North Holland, on the Marsdiep, some leagues from this seat of legendary lore, rests lively and active Helder, with twenty-seven thousand inhabitants. Here is the Dutch Portsmouth; a great naval and military station, containing the stores of the national navy, a cadet school, meteorological college, observatory, and lighthouse.

Almost directly across the big pond in Friesland, is Harlingen, renowned for its butter and cheese, while a little to the east the silk weaving and pottery industries of Franeker rend the air with the music of modern progress. In this little more than hamlet, is a town hall dating back to 1591, where, appropriately enough, reposes the old planetarium, of mid-eighteenth century, made by the native astronomer and mathematician, Else Elsinga.

Further down, in Overyssel, Kampen adds to the memories of the great Netherlands' struggle for liberty. It also has a venerable town hall, and, from the bell tower, at the back, news rang out that the Spaniards had been forced to flee from Leyden; that Dirkzoon had won the battle of Zuyder Zee, and that Briene had fallen before that unique roving rebel navy the "Water Beggars," under William de la Marck, the Dutch John Paul Jones. During the war, this town was much in the limelight, having been repeatedly attacked by the Spaniards, and once occupied by them for a half dozen years.

What effect the transformation from seaports to inland towns will have upon the material welfare of these remarkable places, and what changes, too, will come over the surface of our historical memories environing them, remains to be seen. Holland has fought the sea long and, in the end, always successfully, and she may quite safely be depended upon to wage to a victorious close this latest planned conflict for a mighty province.



North Holland and Frisian Coasts, with the Zuyder Zee, showing areas to be reclaimed

Oxygen in Iron

THE determination of oxygen in iron by heating drillings to redness in a current of pure dry hydrogen gives only the amount which is present as iron oxide; occluded oxygen and oxides of other elements (manganese, silicon) are not affected. The apparatus recommended for the determination comprises a hydrogen cylinder from which the gas passes in succession through two wash-bottles containing alkaline pyrogallol and one containing concentrated sulphuric acid, an unglazed porcelain tube containing fine iron drillings heated in an electric furnace, and two U-tubes containing phosphorus pentoxide. The purified gas then passes over the drillings of the sample to be analyzed, heated in a Mars electric furnace, and through a U-tube with phosphorus pentoxide and a sulphuric acid guard tube. Hydrogen is passed through the apparatus for an hour, after which the temperature of the furnace is raised to 850° to 900° C. in half an hour.

The following results of oxygen estimations are given: Grey cast-iron 0.001-0.005 per cent; Swedish white iron, up to 0.002 per cent; spiegel, 0.008-0.110 per cent; silicospiegel, 0.037 per cent; ferrotungsten, 0.058 per cent; high-speed steel, 0.024 per cent; nickel steel (0.45 per cent C, 25 per cent Ni), 0.020 per cent; ingot-iron, 0.031 per cent; crucible steel (1 per cent C), 0.24 per cent; wrought-iron, 0.217—before the addition of the "killing" elements varied 0.244 per cent. The oxygen content of basic steel just from 0.066 to 0.112 per cent, while after these additions the oxygen present had fallen to 0.014-0.040 per cent. The highest oxygen content ever found by the author in badly overblown basic Bessemer steel was 0.113 per cent, corresponding to 0.51 per cent FeO.—*F. Schmitz, Stahl und Eisen*, No. 38, 1918.

The Functions of the "Sacral Brain" in Dinosaurs*

How Did These Immense Animals Maintain Their Size?

By Richard Swann Lull

BRANCA, in a discussion of the fauna of Tendaguru, East Africa,[1] makes a number of thought-inspiring comments upon the huge sauropod dinosaurs which the formation contains. Among other points he is striving to account for the maintenance of their immense bulk upon a possibly meagre diet by assuming digestive powers of extraordinary efficiency. For this he offers the following explanation:

"One may be inclined to look for the ability to take care of food solely in the stomach, intestines, or liver. However, in the dinosaurs we may take into consideration something else, *i. e.*, the 'sacral brain,' if we look upon the swelling of the spinal column in the sacrum as a 'brain.' According to Waldeyer, it is indeed thinkable that the sacral brain in dinosaurs had a certain independence, and cared for the functions of *nourishment, digestion*, and procreation [italics mine], also that through a particularly strong innervation it had become especially powerful, more powerful than the strongest digestive organs could be without such a sacral brain. In man there appear still to be traces of this, but here the sacral section of the spinal column is completely surpassed by the brain."

What Waldeyer based his argument upon I do not know, but the evidence which I have been able to secure seemingly does not justify such a speculation. This evidence is here presented.

DINOSAURIAN FEEDING HABITS.

Our assumption of feeding habits based upon the character of dinosaurian dentition justifies the following conclusions:

Theropoda.—These are the carnivorous dinosaurs in a strict sense, with teeth which were in the main prehensile and as such confined to the forward portion of the jaws. They must have been used for rending the prey, for in many instances, such as *Allosaurus* or *Megalosaurus*, they are sharp-pointed and compressed, with finely serrated cutting edges. In *Tyrannosaurus* they become so thick that the knife-like edge is gone, so that these huge beasts must have dismembered their prey by tearing rather than by cutting it. These latter theropods are analogous to the crocodiles in dental equipment; *Allosaurus*, on the other hand, possessed a more efficient dentition.

The digestive system of the crocodiles shows the highest degree of specialization of any living reptiles, as the stomach is very muscular, with lateral tendinous discs forming an organ very suggestive of the gizzard of the graminivorous birds. In front of this gizzard-like stomach is a capacious portion of the œsophagus, within which is held the excess of food over the rather small capacity of the stomach. The stomach digestion is highly efficient, due not alone to its muscular power, but to the strength of the gastric juice, so that even the bones of the prey are dissolved and not passed through the intestine, as with certain carnivorous birds like the owls. Crocodiles occasionally swallow stones to aid in the trituration of their food, just as do the graminivorous birds.

To what extent the gizzard was developed in the Theropoda is conjectural, but it would seem as though its need were nearly as great with them as with the crocodiles. One aberrant type of theropod, *Struthiomimus*, from the Pelly River formation of Canada, has just been the subject of an authoritative paper by Professor Osborn.[2] This form is now known to have been absolutely toothless, and several theories have been advanced as to its feeding habits—that it was insectivorous, especially ant-eating, or that it fed on small crustaceans or molluscs of the seashore, or that it was ostrich-like in habits, browsing upon leaves and buds which its prehensile limbs drew within the reach of the horn-sheathed mouth. Such an assumption as the last, which bears the weight of Osborn's own opinion, would seem to imply the presence of a more or less efficient gizzard-like stomach functionally comparable to that of the struthious birds.

Sauropoda.—The sauropods are clearly of theropod derivation, but it has been pretty generally assumed that they had forsaken the carnivorous habits of their forbears for a vegetative diet, and the tremendous growth of certain plants such as the water hyacinth in the Nile or the waters of New Zealand seems to offer an analogy to what might well have been true of certain aquatic vegetation of the Mesozoic upon which these creatures fed. The teeth were now solely prehensile, sufficiently so for their owners' purpose, but less efficient than those of the Theropoda. The food was in no sense masticated and the inference that a powerful muscular gizzard-like stomach was developed is irresistible, for which the presence of stomach stones, gastroliths, within the ribs of more than one specimen may be taken as added argument.

Predentates.—The predentate dinosaurs, on the other hand, had a differentiated mouth armament. The anterior or prehensile portion was toothless, except in *Hypsilophodon*, but was sheathed with a horny, turtle-like, cropping beak of varying form. The posterior portion of the jaws bore the actual dental battery, consisting of a series of successional teeth which also varied in efficiency and degree of development in accordance with their owners' food, as do those of the ungulate mammals. The Jurassic and early Comanchian forms, such as *Camptosaurus* and *Laosaurus*, were analogous to the browsing ungulates whose brachiodont teeth are fittted to succulent herbage, while the later trachodonts had a dental battery fully as efficient as that of a horse. These dinosaurs chopped their food into short lengths before swallowing, and it may be that the term mastication, which, however, implies a grinding or crushing rather than chopping, may be properly applied to them. Their need of a gizzard-like organ would seem to be less great than in the sauropods.

Stegosaurus, on the other hand, possessed a very imperfect dental battery, as the teeth were both small and relatively few in number—very inadequate apparently for their owner's needs. This genus, however, exhibits a number of characters which, in the Sauropoda, have been taken as indicating an aquatic or at least amphibious life. They are, first, the solid, massive character of the limb bones and the imperfection of their articular ends, those of the stegosaur showing a rugosity fully proportional to those of *Brontosaurus*. The high position of the ribs, bringing the lungs well toward the dorsal side of the body, and the strongly compressed tail with its high neural spines and well developed chevrons are also suggestive. Add to these a mouth armament no more effective than that of a sauropod, and the association of their remains in a common burial, and the inference of similarity of habitus and food is perhaps justified. Just what effect the tall upstanding armor plates would have upon the navigable powers of *Stegosaurus* is not so clear, but they may have incommoded him under such conditions no more than on land.

It may be fairly assumed, therefore, in view of the wide apparent range of feeding habits on the part of dinosaurs, and their relationship to the crocodiles on the one hand and to the birds on the other that their digestive system was closely comparable both in the development of its parts and in its innervation to that of these living forms. With the birds, the degree of development of the gizzard varies directly with the consistency of the food. Graminivorous birds possess the strongest muscular layer and the thickest horny lining, while in the series from the insectivorous birds to the birds of prey this condition becomes gradually less marked and the division of labor between the glandular proventriculus and the mechanical gizzard less noticeable (Newton). The assumption of a similar gradation in the development of this organ in the dinosaurs seems also warranted.

INNERVATION OF THE ALIMENTARY CANAL.

In the reptiles such as the python, crocodile, or turtle, the *vagus* nerve (Xth cranial) is the principal transmitter of stimuli which *initiate* digestive activity, certain of its fibers being distributed to the muscles and mucous membrane of the fauces, the œsophagus, and the stomach, and it finally terminates at the beginning of the intestine at the pancreas.

Cranial casts of *Tyrannosaurus*[3] and of *Stegosaurus* and *Morosaurus*, representing, therefore, the three main dinosaurian groups, all show exits for the IXth to XIth cranial nerves, thus including the vagus, relatively larger if anything than in the crocodile. It is fair to assume, therefore, that this nerve was at least as well developed in the dinosaurs and that its distribution and function were comparable.

Birds.—The vagus (X) of birds arises behind the glossopharyngeal (IX) and is connected therewith as well as with the sympathetic system. After receiving branches from the hypoglossal (XII) and taking up the spinal accessory (XI), the vagus runs down the side of the œsophagus to the ventral side of the proventriculus where, joining its fellow from the other side, it spreads out to supply the stomach. Other branches, leaving the principal stem of each vagus, supply the liver, heart, and lungs, and, as the recurrent laryngeal branch, also supply the distal portions of the trachea and œsophagus. Some fibres of the vagus often extend beyond the stomach, and are connected with the sympathetic nerves of the trunk, supplying parts of the intestinal canal. (Newton.)

The approximate agreement in the innervation of both birds and crocodiles is further argument for dinosaurian innervation.

Certain of the spinal nerves (dorso-lumbar) communicate with the sympathetic system and thence with the alimentary canal, but their function, in so far as it has been observed, principally in man and certain mammals, is *inhibitory*, and hence the reverse of a stimulus to digestion. Such sacral nerves as do pass to the alimentary canal are distributed to the hinder portion only, beyond the glandular or digestive part. They are stimulating, not inhibitory nerves, but their function is merely the elimination of fæcal matter and is in no other sense digestive.

The stomach in the mammal at least is largely automatic in its movements, as is the heart, and while its activity may be initiated or inhibited by impulses from the vagus or sympathetic nerves, the stimuli which cause the rhythmic movement originate in the muscles themselves, for this movement will continue after the severance of all nerve connection with the cerebro-spinal or sympathetic centers. The reptilian heart is notorious for its automatic contraction after its excision from the body, and in all probability the heart and stomach of a dinosaur were fully as automatic.

All of this seems to show that we have no right in assuming for the dinosaur an innervation or functioning of the alimentary canal at variance with the standardized type of the living amniotic vertebrates.

The spinal canal of *Stegosaurus ungulatus* has been studied in detail by the author, who finds not only a sacral dilatation but a *brachial* one as well; that is, from vertebræ VIII to XIII, the maximum width, that of 38 mm., as compared with the average of 25 mm., is attained by vertebra XI, which is exactly opposite the shoulder articulations in the Yale mounted specimen. There is also a corresponding heightening of the canal, although this is a less constant feature, for further back (XV and XVII) there is evidence of a ligament or other delimiting structure below the bony roof of the neural arch itself. Brachial and sacral dilatations of the neural canal are most marked in the turtles among existing reptiles, owing to the immobility of the trunk and the consequent reduction of its musculature and associated nerves, the two enlargements being necessary where the nerves depart to the limbs. That this is the whole significance of these two enlargements in *Stegosaurus* and also in other dinosaurs I have no doubt, and the relative size of each dilatation bears an approximate ratio to that of the limbs innervated, plus in the hinder pair the huge caudofemoral and other muscles which actuated the tail.

I still feel, despite the contention of the German writers, that the "sacral brain"—which should not be called by such a term—possessed no unusual function whatever, but only the normal one of transmission and reflex action in an unusual degree, and that to invoke any new and unknown function as a reason for its relatively immense size, especially one connected with digestive efficiency, is not justified by the evidence at hand.

Branca further says:[4] "We may also think of these animals as sluggish in habit, in consequence of which much less food was required than is the case in an active animal." On the other hand, in warm-blooded animals the largest species occur in cooler climates, because large animals have "a relatively smaller radiating surface than smaller ones, a factor of the

*Contributions from the Paleontological Laboratory, Peabody Museum, Yale University, Conn., U. S., from the *Am. Journal of Science*.

[1] W. Branca, Die Riesengrösse sauropoder Dinosaurier vom Tendaguru, ihr Aussterben und die Bedingungen ihrer Entstehung, Archiv für Biontologie, 3 Bd., 1. Heft, 1914, pp. 71-78.

[2] H. F. Osborn, Skeletal adaptations of *Ornitholestes, Struthiomimus, Tyrannosaurus*, Bull. Amer. Mus. Nat. Hist., vol. xliii, 1917, pp. 733-771.

[3] H. F. Osborn, Crania of *Tyrannosaurus and Allosaurus*, Mem. Amer. Mus. Nat. Hist., new series, vol. i, pt. 1, 1912, pp. 1-30.

[4] Loc. cit.

greatest importance in the regulation of body warmth." To the first statement I can take no exception. The second, however, gives food for thought. In the first place, is it an invariable rule that the largest species of warm-blooded animals occur in cooler climates? The present-day distribution of the elephant, hippopotamus, and rhinoceros does not bear this out, and even in the Pleistocene the largest elephants, such as *Elephas imperator*, were southern forms compared with the smaller, cold-adapted *E. primigenius*. With marine creatures Branca's statement seems more nearly true, for the walrus and huge sea-elephants are both adapted to cold waters, and the same is true of the right whales, *Balæna mysticetus and B. australis*. The sperm whale, on the other hand, is tropical or subtropical, not occurring, except accidentally, in the polar regions (Flower and Lydekker), while the great rorquals (Balænoptera) are found in all seas except the Arctic and probably the Antarctic also. Of the deer, perhaps the largest living form is the Alaskan moose, while no bears in existence can compare in magnitude with the great Kadiak bear of the same region. But this argument loses weight if the dinosaurs were not warm-blooded, and though the supposition that they were has been advanced, it is not susceptible of proof. It is within the range of possibility that the temperature of the more agile dinosaurs rose appreciably during the time of their activity, as in many of the so-called cold-blooded (poikilothermous) creatures today, but whether or no any dinosaurs had a mechanism for even a partial maintenance of temperature is unknown. If their bodily heat varied with that of the surrounding air, the greater bulk and hence relatively smaller radiating surface would render them less susceptible to rapid temperature changes, and thus prolong their time of activity by tiding over a brief drop in temperature, but would hardly be available in an extended cooler period. That increase of size in dinosaurs was an adaptation for the conservation of energy, and in this way reduced the relative amount of nourishment necessary for their maintenance, seems hardly probable.

The Wax Palm and Its Uses

By C. D. Mell

THE palms are said to constitute the most important of all the natural plant groups. Every country within the tropical and temperate parts of the world have representatives of this large family of plants and they are utilized everywhere by the inhabitants of the regions in which they grow. As a rule, all parts of these plants are useful for some purpose or other. The roots, trunks, leaves and seeds yield products of no mean values in practically all countries, and it is believed that it will be of interest to the general reader to learn a few facts in reference to the well-known Brazilian palm called arnauba (*Copernicia cerifera*). The local name of this palm is derived from the Portuguese word *carne*, flesh or meat, and from the Tupe Indian word *uba*, meaning tree. This name was given to this palm, because the Indians claimed the root possesses medicinal properties unexcelled as a purifying agent for the blood and as a flesh builder. The specific term, *cerifera*, has reference to the wax-yielding properties of this tree; wax is one of the chief commercial products of this palm.

The carnaube palm grows wild in Brazil, especially in Parahyba, Ceara, Rio Grande del Norte, Piauby and in the neighboring States. It thrives best on areas near the coast where the soil is often a little saline. Like most plants that can grow in salty marshes where the soil may be considered physiologically dry, the wax palm can likewise stand drought to a remarkable degree and there are many dry and more or less upland places in Brazil and other tropical countries where this useful palm now grows and it should be planted on a commercial scale. It was introduced into Ceylon about twenty years ago, where it attracted considerable attention among the planters, because of the numerous advantages of the plant of which each part has a recognized value. The seeds were obtained in Brazil and they grew well, but there are now available an unlimited number of root cuttings for transplanting and it is believed that it will attain considerable commercial importance in Ceylon after the war.

The carnauba wax industry in Brazil is now pretty well established. It is a product chiefly of the young leaves which are about to unfold. At this stage of their growth they are coated with a thin film of glossy vegetable wax. The best quality wax is obtained from the tenderest leaves which are gathered and prepared from September to March. Each tree furnishes about six leaves at each cutting. They are cut by means of pruning shears three times during the season. From 1,500 to 2,000 leaves are required to make from 25 to 30 pounds of first-class wax.

After the leaves have been gathered and graded they are placed in the sun for several days to dry, and in consequence of this they shrink and wither and the coat of wax cracks and falls off in small flakes. The dry leaves are then thoroughly beaten with suitable flails so as to remove all the particles of wax from the surfaces. The wax is then gathered together by sweeping the floor and placing the material thus collected into a tin or earthen ware receptacle half full of boiling water in which these thin films of wax partly dissolve and become a liquid mass which is strained through coarsely-woven cotton cloth thus removing the vegetable tissues and other foreign matter. The strained mass soon dries and becomes hard, brittle and of a light sulphur color with a luster between that of bee's wax and rosin.

The carnauba wax is harder than that obtained from bees. Its color is somewhat darker than what the local trade in Brazil prefer; as a result of this it has not been considered suitable for making first-class candles in Brazil, but the wax has always found many uses in Europe where it has been an article of trade for over 100 years. The first substantial shipments were made from the State of Ceara in 1845, and for a long time after this it was called Ceara wax. The exports from Brazil, chiefly to England, gradually increased until 1872 when the total quantity amounted to 2,000 tons. In 1909 the exports of this product exceeded 3,000 tons. The amounts fluctuate however, and it is safe to say that about 2,500 tons are exported annually, two-thirds of which goes to the United States where it is used for making cylinders for graphophones and phonographs. When bleached it is used for giving firmness to candles which adds brilliancy to the flame. It is used also as an ingredient in the various shoe and leather polishes. As a hard floor polish it is unexcelled.

The value of this wax depends on three factors: Color, composition and richness in oil. The trade classifies the wax in three grades: the first is of a pale-green color of a smooth composition and rich in oil. The other two grades are inferior and are somewhat darker, less uniform in color, a little more porous and have less oil.

The wood from the long slender trunks is very hard, heavy and of a rich dark color. It is used locally for a great variety of purposes. Owing to its great strength and toughness it is preferred for roofing, both as beams and rafters, and as laths upon which to support the tiles. The wood is used also locally as well as in Europe and the United States for small articles, especially for walking sticks and umbrella handles.

The fruit is used locally as an article of diet and it is very pleasing to the natives. The seeds are a coffee substitute. The upper part of the stem which is still young and tender is used as food. The root is highly esteemed by the medical profession as an excellent purifying agent and has proven to be a very valuable remedy for diseases relating to impurity of blood. If this drug were carefully tried it would be a formidable rival for sarsaparilla. The root of the Carnauba also has diuretic properties and is effectively used for the cure of acute or chronic blennorrhea. It is supplied in the form of an infusion, decoction or fluid extract. A flour or starch is also prepared from these roots. From the white liquid which is obtained from the trunk, a beverage is made which is similar to cocoanut milk, while the tender branches are used as forage for sheep and cattle. Finally, the leaves are used by the natives for making from the excellent fibre which they obtain from them, hats, roofs, garments, baskets, brooms and matting. A considerable amount of this fibre is shipped to Europe and part of it returns to Brazil in the shape of hats.

Full-Sized Ship Experiments

NUMEROUS cases are on record where good results have been obtained by alterations made to full-sized ships after they have been completed. Trial trips have been run both before and after the alterations and in this way a trustworthy estimate has been made of the difference in performance.

At the spring meetings of the Naval Architects last year Sir E. Tennyson d'Eyncourt, for instance, recalled the case of two ships built about 17 years ago. After they had been in service for some time he suggested that the bossing, which was nearly horizontal, was not at a suitable angle. On one of the ships coming back to the works it was, therefore, decided to alter the angle to something approaching 45 deg., and, in addition, the casting was fined at the aft end as well as the lines of the bossing itself. At higher speeds much better results were obtained than with the old horizontal bossing, but the improvement did not maintain itself at lower speeds. This showed that the improvement was due to the angle of the bossing and not to the general fining of the lines. After the ship had been on service for some time it was found that so much coal had been saved that her sister-ship was sent to have a similar alteration made to her bossing.

BILGE KEELS.

Sir Archibald Denny at the North-East Coast Institution of Engineers and Shipbuilders in November, 1915, instanced a rather curious case of alterations made to a full-sized ship where it was found that the bad performance of the vessel was not due to the suspected cause but to something entirely different. When the vessel was built her bilge keels, which were very long, were not put on normal to the bilge, as they would have come out of water at the ends, the angle of the dingonal plane of the keel being reduced. When the vessel was tried on the measured mile her efficiency was found to be very low. Some one suggested that the bilge keels were the cause of the trouble, and a length of 20 ft. was cut off from each end of both of them. This causing no appreciable difference, the bilge keels were taken off altogether, and the reduction in the resistance was found as nearly as possible to be quite normal. Later it was seen that there was a lack of surface in the propellers, and when new propellers were put on the efficiency came up to expectations. This, however, did not explain the fact that in an almost identical ship with similar propellers proper results had been obtained, and Sir Archibald Denny has stated that to this day he is not able to explain with certainty why the results were so different. Another case quoted by him was that of a Channel steamer. In order to get the maximum result mastic was placed behind each butt and washed off into the general surface, and this was done for some years. But when the mastic cracked off it was not replaced, because there was no apparent difference in the speed on service with or without it.

ALTERATIONS IN PROPELLERS.

Admiral Taylor, in his "Speed and Power of Ships," refers to the steamer Niagara, a yacht about 250 ft. long, in which the shaft brackets were nearly horizontal. She was given two six-hours trials under similar conditions. In the first the screws were inward-turning and in the second were interchanged to be outward-turning. The horsepower developed on each trial was very nearly the same, but with the inward-turning screws the average speed was 12.8 knots, whereas it was 14.12 knots with outward-turning screws.

Captain Dyson, the propeller designer to the American Navy, has instanced a case of two oil-fuel barges built for the Navy Department. These vessels were designed for a speed of six knots, and everything indicated that the speed could be easily obtained with the power. After trying several different propellers, however, the highest speed realized was only 5¼ knots. It was thought that the action of the water indicated that a portion of the feed was being drawn from astern, and as the cheapest remedy the line of shafting was changed so as to lower the propeller about 3 ft., although the lower blade projected below the line of keel. In this new position, with propellers of the same pitch and surface but of 6 in. greater diameter, a speed of 6¼ knots was obtained with the same power as before. The greater portion of this increase in efficiency of the propeller was due to increase in diameter, and the remainder to the change in position, but the increase in diameter was rendered possible by the lowering of the shaft.

Many other examples could be given, but those mentioned are sufficient to show the benefits that may be derived by making alterations in consequence of careful observation of a ship's behavior in service. The cost of carrying out the alterations must vary, and in some cases will no doubt amount to a fair figure. On the other hand, the large saving brought about by the reduced fuel consumption, which operates during the whole lifetime of a ship, will more than balance even a considerably outlay on such alterations. When this is generally realized it can be confidently stated that enormous economies will be effected in ship propulsion.—*London Times Engineering Supplement.*

Black Dyeing on Iron Mordant

A BLACK, which possesses the advantage of satisfying all requirements as regards fastness and not injuring the wearing qualities of the most delicate fabrics, is produced by dyeing a mixture of alizarin and dinitroresorcinol on an iron mordant.—*O. Drehl in Z. Aug. Chem.*

A Surface Having Only a Single Side*

An Investigation of a Curious Geometrical Problem

By Carl Hering, D.Sc., Member of the Institute

ALL the usual surfaces with which we are familiar have two sides; a sheet or shell having no appreciable thickness is representative of the mathematician's surface; one side could be colored differently from the other; mathematicians recognize this two-sided property when they refer to the two normals at a point of a surface as differing only in their algebraic signs. The surface of a sphere must be considered as a shell, therefore having an outer, convex, or positive side, and an inner, concave, or negative side.

It is quite simple, however, to devise a true surface which has only one side, and as this has some very odd and peculiar properties the following description of it may be of interest; and when this surface is better understood perhaps some applications of it may be found. Steinmetz in the *Journal of the American Chemical Society*, May, 1918, p. 733, for instance, showed how this and the Riemann surface, on account of their peculiar properties, can be used for illustrating some of the complicated relations in the periodic system of the chemical elements.

If the two ends of a strip of paper or of a flat ribbon be brought together to form a ring, and a twist of half a turn be given to it before the ends are secured together, such a single sided surface (and with only a single edge) is produced. But this form of it is geometrically quite complex and irregular, because the paper does not bend edgewise, and it therefore does not lend itself well to an analytical investigation; it is doubtless for this reason that it had apparently not received the attention it deserves. In order to study the peculiarities of this odd form of surface, the writer constructed numerous models of what he considers to be the simplest type of the geometrically most regular form of it; this regular form, it seems, had not been investigated analytically before.

Let *C*, *C*, Fig. 1, represent a circle shown in perspective. Let a straight line *ab* start from the position 1 in the plane of this circle; let this line be moved as a generatrix of the surface, along the circle as a directrix and always remain in planes passing through the axis of the circle. Simultaneously with this motion let it revolve around this circle as its axis and at *half* the angular rate of its movement around the circle. Hence, when it has moved 90° around the circle, clockwise, into the position 2, it will be inclined 45°, clockwise, to the plane of the circle; in the position 3 it will be perpendicular to this plane; in the position 4 it will be inclined 135°, and when it arrives at the origin again it will have revolved 180° in its own plane; hence, will coincide with its original position 1, but *will be reversed* in its direction, as is shown in the nearby dotted position 5.

The surface thus described seems to be the simplest geometrically regular form of this one-sided surface, and as its generation follows a regular law it lends itself to analytical investigation. A carved wooden model of this surface when the generatrix *ab* is of a limited length and much less than the diameter of the circle, is shown in Fig. 2, it being then a ring; it of course also has only a single edge. The white zone in the middle represents the centre-line circle, although distorted somewhat on account of the thickness of the ring required to give it strength.

In Fig. 1, the lines *ab* in positions 2 and 4 are in fact parallel, and they are necessarily so in a model constructed in space, but geometrically the line has in fact revolved 90° around its circular axis in passing from 2 to 4; this will be evident if one imagines oneself moving along with the line and always facing it; hence, for position 4 one is supposed to be looking at it from the rear, or from the reversed side of the paper as though it were transparent. With a solid model, such as Fig. 2, this is readily seen by turning the model in the plane of the circle while following the revolving line. It is, therefore, only apparent and not real that the line does not change its direction in passing from positions 2 to 4 through 3, and that it reverses its direction completely in passing from 4 to 2 through 1.

Geometrically considered the straight line generatrix *ab* is of course of infinite length, but to study this peculiar surface it is best to first start with that limited portion of it which will form a ring, Fig. 2, which will be the case when the length of the line *ab* (the width of the ring) is considerably less than twice the diameter of the circular directrix; this line must necessarily extend equally to both sides of the circle, or else no continuous and uniform ring will be formed.

If such a ring were made of a dielectric and completely covered to near the edge with tin foil, it would not act as an electrical condenser. Hence if an ordinary surface be characterized as bipolar because it has two sides which are algebraically or geometrically of an opposite nature, the present surface would need to be called non-polar or uni-polar. This is its chief peculiar characteristic and places it in an entirely different class of surfaces. For instance, a pin stuck vertically through such a surface would at first seem to represent two normals of opposite sign at the same point; but as the apparently two sides are really one, the pin in fact constitutes two normals at two different points on the *same* side of the surface, which two points coincide in space; relatively to the surface these two normals are like the two outward extensions of a diameter of a spherical shell, and as the two latter may be said to have the same polarity with reference to the shell (if this term may be used as meaning the same direction relatively to the surface, and from the same side of a surface), then the two normals represented by the pin through this ring also have the same polarity, in which respect they differ radically from the two normals represented by a pin stuck through a spherical shell, the two parts of which would have opposite polarities. The present surface simply has no "other side" and is therefore radically different from the usual ones; if one were to paint one complete side of such a ring one would find that there was no unpainted side left.

If such a ring when made of something flexible, like paper, be cut along the centre-line circle, it will form only one ring of double the diameter.[1] This large ring has then lost the characteristics of this surface, as it has two sides like the usual surfaces; it has four half twists instead of one. Hence, if the present ring, Fig. 2, were covered with tin foil and the foil be cut along the centre-line circle, it would act as a condenser. Or if the ring be colored on the half to only one side of the centre-line circle and then cut as before, it would form a ring which is colored on one side and white on the other. Merely cutting this surface along its centre-line circle, therefore, puts it into the same class as the usual surfaces. This anomaly applies only to limited portions of this surface like this ring.

If such a ring be made of paper it could be given any number of half twists before joining the ends. All those in which the number of half twists is an odd one belong to this class; those with an even number belong to the usual class of surfaces. When given three half twists and then cut as before the double-size ring will be found to have a regular knot tied into it. Instead of using a line *ab* as the generatrix it may be a regular polygon, like a triangle, square, etc., and the twists may then be in thirds, quarters, etc.; this, however, leads to solids as distinguished from surfaces.

Mechanically the centre of gravity of such a ring (considered now as having an appreciable thickness) is at its geometric centre; hence, when revolved around its axis it will be perfectly balanced statically. When thus revolved, it forms an excellent model for showing the characteristic motions in a vortex ring. It is statically balanced also around position 1 as an axis.

Cut in two along an axial plane through the original position 1 in Fig. 1, the two halves are identical in shape; also when cut in two by a plane through the original position and perpendicular to the axis. To make such a ring accurately and without internal strains, it is best to start with a tore (a circular ring of circular cross section), mark off on its surface where the edges will be (according to the law explained in connection with Fig. 1), and then cut away the material down to those lines. A fairly close approximation may be made far more simply from paper, cardboard or sheet metal, by cutting it to the horse-shoe shape, as in Fig. 3 (the approximate development of this surface), and bringing the edges together, *a* to *a* and *b* to *b*. There are, of course, two possible directions of the twist, a right and a left. The ring may also be conceived to be formed of a straight helix (like the usual twist drill) with a half twist, and then bent around to make its axis a circle.

Such rings are only limited portions of this surface in the form of zones. In order to obtain an idea of this surface when extended to infinity the writer made the wire model shown in different position in Figs. 4, 5, 6 and 7. Beyond the limits of these wires, to infinity, there is nothing of interest, as all the geometric contortions which this surface must go through in order to have only one side are within and near the circular directrix. The sixteen regularly spaced straight wires are all of the same length and are bisected by the circular directrix; the solid ring is

Fig. 1

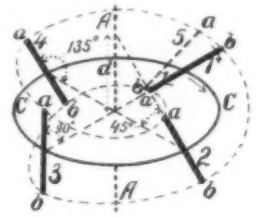
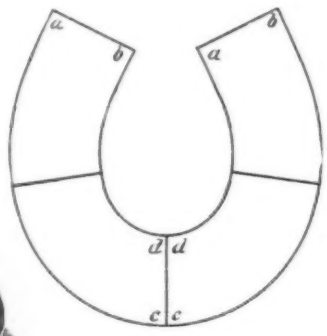
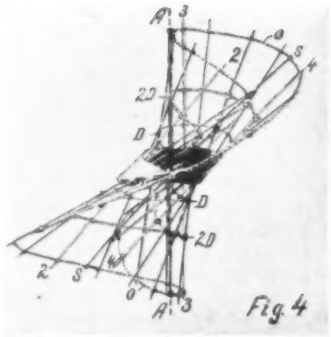


Fig. 2

Fig. 3





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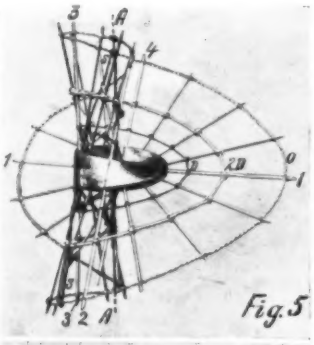


Fig. 5

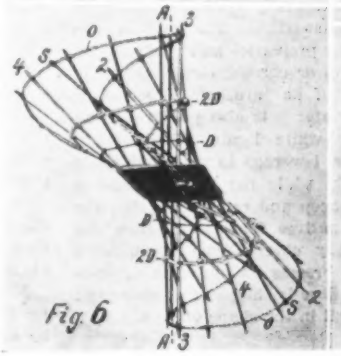


Fig. 6

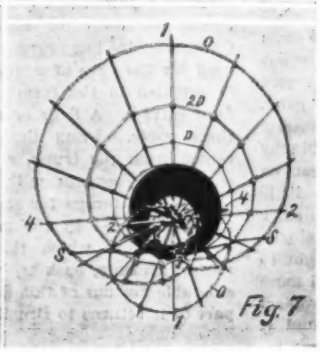


Fig. 7

*Reprinted by permission from the Journal of The Franklin Institute, August and November, 1918.

[1] This and other features of popular interest were described by the writer in an article on "A Flat Band With Only One Surface and One Edge"; in the SCIENTIFIC AMERICAN, Feb. 21, 1914, p. 156.

merely to hold them in position. In all of them the four chief or cardinal positions of the straight line generatrix are numbered as in Fig. 1; *A* is the axis.

Fig. 4 is nearly in line with the original position 1, and shows the tangential axis *A*. Fig. 5 is about a quarter turn from the former and is nearly in line with the plane of the position 2; it shows the parallelism of positions 2 and 4, and with the intersection *S*. Fig. 6 is about a half turn from position 1 and therefore nearly in line with position 3; it shows the intersecting line *S*. Fig. 7 is approximately from the top, and shows chiefly the edges of the zones of various widths.

The three cords stretched between the wires show the shapes of limited portions or zones like the ring in Fig. 2, extending equal distances to both sides of the circle. The width of the outer zone *O* is nearly four times the diameter of the circular directrix; it shows the general shape of the surface as it passes out to infinity after having gone through its contortions. It will be seen from the top view, Fig. 7, that the edge makes three turns of 360° in completing its circuit; it intersects the axis twice and the intersection *S* four times. The width of the next smaller band *2D* is twice the diameter of the circle; hence, it intersects that circle; its edge again makes three turns to complete its circuit and also intersects the axis twice; it intersects the intersection *S* only twice and is tangent to it once.

The width of the next one, *D*, is equal to the diameter of the circle; hence, it meets the axis only once and at this point the axis is tangent to the edge of the ring; it intersects the intersection *S* twice; in this and all smaller ones the edges make only two turns of 360° to complete their circuits, the third loop of *D* now having contracted into the point of tangency with the axis. In this one the part of the surface which is near the axis is for a short distance practically in an axial plane, and it is the only ring in which this is the case. Mechanically this one is of interest as it can be secured at this tangential edge to a shaft for revolving it, hence without the spokes required for the smaller ones.

Rings of less width than the diameter of the circle are all like the solid ring in the model, that is, like Fig. 2, whose width is a little less than half the diameter; as in the case of ring *D*, their edges make only two turns in the complete circuit; they do not intersect the axis at all. The limiting ring is, of course, the circular directrix itself.

The axis *A* is throughout its whole length tangent to the surface, as every position of the generatrix, of course, intersects it. This is of interest in that it shows that this much-curved surface has a second straight line element besides the generatrix. This feature enables this surface to be defined algebraically as one generated by a right line, *ab*, Fig. 1, intersecting the axis, *A*, at different angles and revolving around it so that the axial distance, *d* (shown for position 2), from the normal position 1 is always equal to the tangent of half the angle, *e*, of revolution of its plane from that of the normal position 1; and the angle it makes with the axis is always the complement of the angle *e*/2. This way of defining it eliminates the circular directrix and shows it to be related to helical surfaces.

This surface must necessarily intersect itself when its width (measured in the axial planes) is greater than twice the diameter of the circle. A curious feature is that the self-intersection of this much-curved surface is a straight line, *S*, making an angle of 45° with the plane of the circle, and lying in a plane tangent to it and perpendicular to the original position 1 of the generatrix. Hence, this surface contains three parallel lines, positions 2, 4, and this intersection *S;* the latter is equally distant from the other two, and the two planes through it and each of the other two are at right angles to each other.

As every position of the right line generatrix must intersect this line of intersection *S* and also the axis, it follows that this surface may also be defined as one generated by a right line generatrix always intersecting two other non-intersecting right line directrixes, each of which makes an angle of 45° with the plane of the other and the normal between them; and that it advances along these lines at certain different trigonometric rates. This also eliminates the circular directrix and shows the surface to be related to warped surfaces. There appear to be no other right lines on this surface than those described.

As the self intersection *S* is a straight line, then it follows that this surface can also be defined as one generated by a right line which is moved so as to always be in contact with two other right lines and a circle, one of which lines is the axis of the circle and the other is inclined 45° to the plane of the circle and lying in a plane tangential to the circle. This way of defining it eliminates all angles and trigonometric functions.

Another odd feature is that the unlimited surface has two trumpet-shaped, clear, passages through it which are completely separated from each other, such that one liquid might be passed through one of them and another through the other without mixing. This might at first appear inconsistent with the statement made above concerning the condenser action, as these two liquids could now act as the two poles of a condenser. From the model, however, it is readily seen that the formation of these two passages is due to the fact that the surface intersects itself.

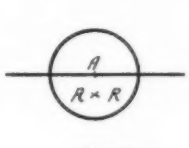


Fig. 8

Fig. 9

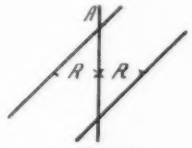


Fig. 10

Fig. 11

Fig. 12

Fig. 13

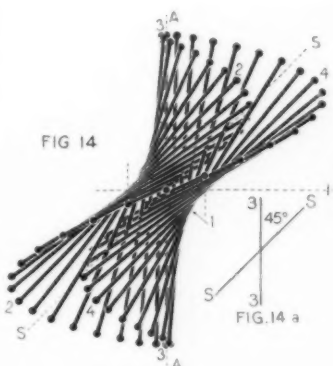


FIG. 14 a

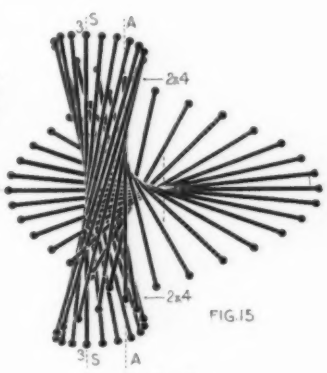
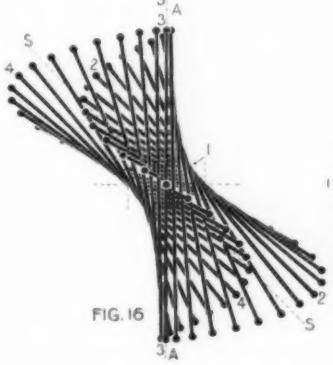


FIG. 15



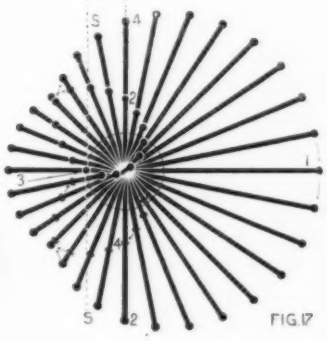


FIG. 17

The principal cross sections of this surface are shown in Figs. 8 to 13, in all of which *R* is the radius of the circle, *A* the axis, and *S* the line of self-intersection; the right lines, of course, extend to infinity in both directions. Fig. 8 is in the plane of the circle; this seems to be the only section in which there is a perfect circle. Fig. 9 is in the axial plane through the original position 1. Fig. 10 is in the plane of the two 45° positions 2 and 4, Fig. 1. Fig. 11 is in the axial plane half way between those of Figs. 9 and 10. Fig. 12 is in a plane through the line of intersection *S* and the original position 1, and Fig. 13 through this same line *S* and either of the two 45° positions 2 and 4, Fig. 1; the normal distance between these parallel lines is equal to $R\sqrt{1.500}$. The sections parallel to the plane of the circle are, of course, all curved loops, each intersecting itself and then passing off to infinity in nearly opposite directions, but they seem to be of no particular interest. The shapes of the edges of the various rings or zones projected on the plane of the circle are seen in the top view, Fig. 7.

When referred to three coördinates, one parallel to the axis, the other parallel to the position 1, and the third perpendicular to both of the others, then the surface is cut three times by every coördinate except the axis itself, which is a tangent throughout, and position 1, which lies entirely on the surface. The algebraic equation of this surface is therefore one of the third degree.

(In an Addendum to this article published in a later issue of the Journal of The Franklin Institute, the author gives the following additional information and drawings. Ed.)

It is difficult to show this peculiarly curved surface by means of flat drawings other than stereoscopic views. Nor can it be shown by a shaded drawing as though made of cardboard, as it is in a sense hollow, or more correctly, doubly hollow; it should be shown as though transparent. The accompanying diagrams, Figs. 14, 15, 16 and 17, were therefore drawn accurately to scale showing it in the form of a succession of lines or rods representing its rectilinear elements in their successive positions in developing this surface. This gives the desired effect of transparency, and by making use of the conventional shading and the knobs at the ends, and by showing the self-intersection, *S*, the desired stereoscopic effect is at least approached.

The two slanting, neighboring, trumpet-shaped holes or passages through it, which in a sense make it doubly hollow, unfortunately cannot be shown as openings in any of these drawings, each of which is taken perpendicularly to some one of the four cardinal positions of the elements. These passages can be seen best in Fig. 16 when one conceives that the row of knobs through the middle represents a series of elements forming a partition which divides the tubular interior into two oblique pasages.

In all of these figures the four cardinal positions, 1, 2, 3 and 4 of Fig. 1, are marked with their respective numbers. *AA* represents the central axis and *SS* the line along which this surface intersects itself. The lengths of the elements were made equal to four times the diameter of the circular directrix which is shown in Fig. 17; beyond that distance there is nothing more of interest.

Fig. 14, corresponding to the former Fig. 4, is a view in line with position 1 of Fig. 1, taken from the right, while Fig. 16, corresponding to the former Fig. 6, is the same taken from the left. Fig. 15, corresponding to the former Fig. 5, is taken in line with the plane of 2 and 4 (which two positions coincide in this view), hence is a view of Fig. 14 from the left, or of Fig. 16 from the right; it shows the two trumpet-shaped and the two fan-shaped parts. Fig. 17 is the top view of Fig. 15 in line with the axis; each of the positions in this view necessarily represents two diametrically opposite elements which therefore partially overlap; the knobs indicate the ends of these super-imposed elements.

From the group of rectilinear cross sections, Figs. 8 to 13 in the earlier article, one was overlooked; it is the vertical section through the position 3 and the line of intersection *SS*, hence perpendicular to position 1; it is a cross section of Fig. 14 parallel to the plane of the paper and slightly to the rear of it; it is shown on a reduced scale in the supplementary Fig. 14a. It is one of the simplest of these cross sections.

In discussing this surface with N. W. Akimoff just before the earlier article went to press, he evolved an algebraic equation for it which time did not then permit to reduce to its simplest form. Since then it has been investigated more thoroughly. Dr. C. P. Steinmetz subsequently reduced it to the following form:

$$y(y+z)^2-y(r+x)^2+2x(y+z)(r+x)=O$$

The writer has reduced it to the following, which he believes to be its simplest form in rectlinear coördinates:

$$y(x^2+y^2+z^2-r^2)+2z(x^2+y^2+rx)=O$$

In these the geometric centre of the surface is at the origin of the system of coördinates, and the circle of radius *r* is in the plane of *X* and *Y;* hence the axis *A* in the figures is the axis of coördinates *Z*; position 1 lies in the positive direction of *X*. Both of the angular motions are assumed to be clockwise, as shown in

Fig. 1; when one is clockwise and the other anti-clockwise the only change in the latter equation is that the sign before the $2z$ is negative.

Inserting in this equation $x=-r$ gives $y=-z$, which proves mathematically that the self-intersection of this curved surface is a right line lying in a plane perpendicular to position 1 and through position 3; and that it makes an angle of 45° with the horizontal or vertical, as shown in Fig. 14a. The result $y=-z$ also shows that it lies in the quadrants $+z$, $-y$, and $+y$, $-z$, all of which will be seen to be confirmed in the drawings by the line *SS*, and was first noticed by the writer in the models.

In all the above the clockwise direction was assumed for both of the angular motions, as described in connection with Fig. 1; if both directions are anti-clockwise the results will, of course, be the same as before; but if one is clockwise and the other anti-clockwise this line of self-intersection *SS* will lie in the other pair of quadrants, that is, will be at right angles to its position in Fig. 14a, and its equation will then be $y=z$, as the sign before $2z$ in the above equation is then – instead of +. These two forms of this surface bear the same relations to each other as a right- and a left-handed screw thread.

As an additional proof of this curious rectilinear self-intersection, the writer started with the assumption that it was this 45° right line and developed the equation of a surface generated by the movement of a right line so that it always touches: (*a*) a circle, (*b*) the axis of the circle, and (*c*) a right line making an angle of 45° with the plane of the circle and lying in a plane tangential to the circle. The equation thus obtained was identical with the second one given above. The same surface may therefore be correctly defined in either way.

The above equations were furthermore tested by deducing from them the cross sections, Figs. 8, 9 and 10. Making $z=o$ gives the equation of the section Fig. 8. Making $y=o$ gives the equation of the section Fig. 9. Making $x=o$ gives the equation of the section Fig. 10.

Using polar coördinates in the plane of the circular directrix (the plane of *X* and *Y*, see Fig. 17), and letting a be the angle of the projection of an element on that plane measured clockwise from position 1, R the radius vector of the projection of any point of that element, and z as before the vertical distance of that point above or below this plane, then the equation reduces to the much simpler forms:

$$z=(r-R)\tan \tfrac{1}{2}a$$

$$z=(R-r)\cot a-(R-r)\operatorname{cosecant} a$$

from which the value of z of that point may be easily determined. The first expression is the more convenient for arithmetical calculations, care being given to the signs and to the directions of rotation; it also follows directly from one of the ways of defining this surface. The second expression gives a completely graphical and very simple solution, for by striking an arc through the point in question with a radius of $R-r$, using as a centre the point of intersection of the radius vector R with the circular directrix, and drawing the necessary cotangent, the quantities $(R-r)\cot a$ and $(R-r)\operatorname{cosecant} a$, are given graphically, and as the lines representing them intersect, their difference, namely the desired value of z, is readily measured off. "Descriptive geometry," so-called, provides another completely graphical solution.

The Examination of Organic Developing Agents*

Methods for Identifying Them and Distinguishing Their Qualities

By H. T. Clarke

From the time that the European war cut off the supply of foreign organic chemicals to this country, two distinct activities have been apparent in the photographic developing agent trade; on the one hand, the efforts of manufacturing concerns to produce the most necessary substances, like hydroquinone and salts of *p*-aminophenol, and, on the other, the less commendable manipulations of the purveyors of bogus and adulterated developing agents. For the control of both of these activities chemists are necessary—to check the purity of the genuine products and expose the composition of the false. Moreover, in many cases developing agents are submitted under fancy names and it is necessary to identify the substances they contain.

The work of the analyst thus falls into three classes: the separation and identification of genuine developing agents; the quantitative determination of such substances; and the identification of the materials employed for adulteration or substitution.

The following scheme for the identification of the commoner developing agents is drawn up to meet the first; a few suggestions for quantitative work follow; but owing to the enormous number and variety of adulterants, no attempt can be made to indicate all of the methods employed for their detection and estimation, which in any case are subject to the methods of routine analysis.

QUALITATIVE METHODS—GROUP TESTS.

Taking 0.1 g. of sample:

I—Insoluble in 5 cc. of cold water:
- *p*-Hydroxylphenyl glycine

II—Soluble in 5 cc. of ether:
- Hydroquinone
- Chlorohydroquinone
- Catechol
- Pyrogallol

III—Soluble in 5 cc. of alcohol:
- *p*-Aminophenol base
- *p*-Aminophenol hydrochloride
- 5-Amino-2-cresol hydrochloride
- 2,4-Diaminophenol hydrochloride
- *p*-Dimethylaminophenol oxalate

III*a*—Insoluble in alcohol:
- *p*-Aminophenol sulfate
- 5-Amino-2-cresol sulfate
- *p*-Methylaminophenol sulfate
- *p*-Dimethylaminophenol sulfate
- *o*-Methylaminophenol sulfate
- *p*-Phenylenediamine hydrochloride

DISTINGUISHING TESTS.

(A) Test aqueous solutions with litmus: Neutral or only faintly acid with Group II; Groups III and III*a* give markedly acid solutions (with the exception of pure *p*-aminophenol base). Test aqueous solutions for chlorides, sulfate, oxalate, and other common anions.

(B) Treat 0.1 g. in 1 cc. hot water with one or two drops of 10 per cent. sodium carbonate solution, and let mixture stand a few minutes to cool.

Group I. *p-Hydroxyphenylglycine*—Dissolves with effervescence; very little change on standing.

Group II. *Hydroquinone, Chlorohydroquinone, and Catechol*—No effervescence; solution darkens slowly on standing.

Pyrogallol—No effervescence, solution darkens rapidly on standing.

Groups III and III*a*—All cause effervescence except pure *p-aminophenol* base.

Crystalline precipitates formed on cooling: Salts of *p-aminophenol, 5-amino-2-cresol* and *o-methylaminophenol.*

No precipitate on cooling: Salts of *2,4-diaminophenol, p-methylaminophenol, p-dimethylaminophenol,* and *p-phenylenediamine.*

(C) To 0.1 g of sample in 2 cc. of water add a few drops of 10 per cent. ferric chloride solution.

Group I—*p-Hydroxyphenylglycine* gives no color reaction in the cold; odor of quinone on boiling.

Group II—*Hydroquinone* gives dark greenish precipitate of quinhydrone in the cold; strong odor of quinone on boiling.

Chlorohydroquinone gives reddish brown coloration in the cold, odor resembling that of quinone on boiling.

Catechol gives a green coloration with one drop of ferric chloride; with excess a nearly black precipitate is formed; no odor is produced on boiling.

Pyrogallol gives intense reddish brown coloration in the cold; no odor on boiling.

Groups III and III*a*—Salts of *p-aminophenol* and *5-amino-2-cresol* give purple colorations in the cold; odors of quinone on boiling; the purple colors are not destroyed.

p-Methylaminophenol sulfate behaves similarly, except that the purple coloration is developed more slowly.

Salts of *p-dimethylaminophenol* give no color in the cold; the solution darkens on boiling, with formation of quinone odor.

With *2,4-diaminophenol hydrochloride* an intense red color is developed in the cold; no odor is produced on boiling.

With *o-methylaminophenol sulfate* a dark purple color is produced, turning to red-brown on standing or more rapidly on warming. No odor is produced on boiling.

With *p-phenylenediamine hydrochloride* a deep green color is developed, followed immediately by a dull purple; on boiling, the color changes to a dull reddish brown, and the odor of quinone is produced.

(D) To 0.1 g. of sample in 1 cc. of water add 2 cc. of 5 per cent. silver nitrate solution.

Group I—*p-Hydroxyphenylglycine* in suspension causes a black deposit in the cold which, on boiling, instantly becomes light brown, while the liquid rapidly acquires a purple color.

Group II—*Hydroquinone* gives a silky white precipitate in the cold; the odor of quinone is developed on boiling.

Chlorohydroquinone scarcely reduces silver nitrate in the cold, but rapidly on boiling.

Catechol slowly reduces the reagent in the cold; no characteristic color or odor developed in boiling.

Pyrogallol causes instant reduction in the cold, giving a brown precipitate; no odor produced on boiling.

Groups III and III*a*—Salts of *p-aminophenol, p-methylaminophenol* and *5-amino-2-cresol* give purple colorations, with quinone-like odors on boiling.

Salts of *p-dimethylaminophenol* give no color in the cold; on boiling, a brownish red color and the odor of quinone are developed.

2,4-Diaminophenol hydrochloride yields an intense red color; no odor on boiling.

o-Methylaminophenol sulfate gives a yellowish brown color in the cold, becoming reddish brown on heating; no odor developed on boiling.

p-Phenylenediamine hydrochloride yields in the cold a transitory pale green color, followed instantly by a deep purple; no color change and no odor on boiling.

SPECIFIC TESTS.

Two reactions which should be performed with every developing agent are acetylation and benzoylation.

In acetylation the substance is mixed with about three times its weight of acetic anhydride, together, if the developing agent be a salt of a base, with an equal weight of anhydrous sodium acetate, and the mixture gently boiled for a few instants over a flame. After the mass has cooled, about ten volumes of water are added and the separated solid filtered off and recrystallized from alcohol or similar solvent.

In benzoylation (Schotten-Baumann process) the substance is mixed with about four times its weight of benzoyl chloride, and an excess of 10 per cent. caustic soda solution added, whereupon the mixture is vigorously shaken in a stoppered tube, cooling if necessary, and occasionally releasing any excess pressure by opening the stopper. Shaking must be continued until the irritating odor of the benzoyl chloride has disappeard. Care must be taken that an excess of alkali is present at the end of the reaction. The separated solid is then filtered off, washed with water, and recrystallized from acetone or other suitable solvent.

The derivatives thus produced possess characteristic melting points, so that any identification can be definitely established by their aid.

Group I—*p-Hydroxyphenylglycine* dissolves readily in dilute sodium carbonate, sodium hydroxide, sodium sulfite, or ammonia; also in dilute mineral acids, but not in dilute acetic acid. When pure it crystallizes in colorless leaflets, melting indistinctly with decomposition above 200°.

Group II—the four substances described in this group all form bright yellow, water-soluble compounds with sulfurous acid (or sodium bisulfite and dilute acid).

Hydroquinone crystallizes readily from water in colorless needles melting at 169°. It boils at 285°. The vapor is almost odorless. It is insoluble in benzene. Quinhydrone, precipitated by a cold acid solution of ferric chloride, or of potassium bichromate, melts at 171°. Quinone, formed by the action of an excess of acid bichromate, melts at 116°. The diacetyl derivative melts at 123°; the dibenzoyl derivative melts at 199°.

Chlorohydroquinone is too soluble in water to crys-

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tallize from aqueous solution. It dissolves readily in warm benzene. It melts at 106° and boils at 263°. The vapor has a distinct phenolic odor. The diacetyl derivative melts at 99°. Chloroquinone, produced by oxidizing with acid bichromate, melts at 57°.

Catechol forms feathery needles which melt at 104° and boil at 245° and are extremely soluble in water. It is readily soluble in hot benzene, sparingly in cold. It possesses an odor resembling that of pyrogallol. On treatment with bromine in carbon tetrachloride solution, hydrogen bromide is evolved, and a tetrabromo derivative melting at 192° is produced. The diacetyl derivative melts at 63°; the dibenzoyl derivative melts at 84°.

Pyrogallol is extremely soluble in water. It is slightly soluble in hot benzene, almost insoluble in cold. It melts at 133° and boils at 293°. It possesses a peculiar and characteristic odor. Its aqueous solution gives a blue precipitate with ferrous sulfate. The triacetyl derivative melts at 161°; the tribenzoyl derivative melts at 89°.

Groups III and III*a*. *p-Aminophenol and Its Salts*—The free base crystallizes from water in leaflets, melting with decomposition at 184°, soluble in about 100 parts of cold water. It is moderately soluble in hot alcohol, sparingly in ether. The hydrochloride crystallizes in prisms, and is sparingly soluble in concentrated hydrochloric acid. The sulfate, crystallizing in fine needles, is less soluble in cold water than the hydrochloride, but the hydrochloride is precipitated from an aqueous solution of the sulfate on adding concentrated hydrochloric acid. On adding to a cold, slightly acid solution an excess of sodium acetate and then a few drops of benzaldehyde, the pale yellow benzylidene derivative is soon precipitated, which crystallizes from methyl alcohol in needles melting at 183°. The diacetyl derivative melts at 150°; the dibenzoyl derivative melts at 234°.

5-*Amino-2-cresol* and its salts resemble *p*-aminophenol and its corresponding salts very closely in solubility and chemical behavior. The free base crystallizes from water in flat needles melting with decomposition at 176°. The hydrochloride crystallizes either in needles, or, less frequently, in leaflets. The sulfate crystallizes in fine needles. On oxidation with acid bichromate it yields toluquinone melting at 68°. The benzylidene derivative is markedly less soluble than benzylidene-*p*-aminophenol in methyl alcohol, from which it crystallizes in leaflets melting at 208°. The diacetyl derivative melts at 103°; on gentle hydrolysis with alkali it yields the monoacetyl derivative melting at 179°. The dibenzoyl derivative melts at 194°.

2,4-*Diaminophenol* is met with only as the hydrochloride. The free base is not precipitated from solution on addition of sodium carbonate; the neutralized solution darkens very rapidly in air. The hydrochloride is sparingly soluble in concentrated hydrochloric acid. Attempts to prepare a benzylidene derivative led to a smeary yellow product. The triacetyl derivative melts at 180°; the tribenzoyl derivative melts at 231°.

p-Methylaminophenol is met with only as the sulfate, which crystallizes in fine needles. The free base is fairly readily soluble in cold water, but is precipitated on neutralizing a cold saturated solution of the sulfate with sodium carbonate; it melts at 85° and is extremely soluble in ether. On allowing a solution in an excess of sodium hydroxide to stand in air, a dark color rapidly develops, accompanied by a characteristic odor not unlike that of a trace of pyridine. On adding sodium nitrate solution in slight excess to a solution acidified with sulfuric acid, the sparingly soluble nitroso derivative separates in colorless needles melting at 136°. The perfectly pure monomethyl compound yields no benzylidene derivative on treatment with sodium acetate and benzaldehyde, but technical samples are rarely entirely free from salts of *p*-aminophenol, which is converted by benzaldehyde into the insoluble benzylidene *p*-aminophenol. A good technical sample should be completely soluble in three parts of concentrated hydrochloric acid. The diacetyl derivative is insoluble in cold water and melts at 97°; on gentle hydrolysis by warming with dilute alkali this is converted in the monoacetyl compound (soluble in alkali and precipitated by acid) which melts at 240°. The dibenzoyl derivative melts at 173°.

p-Dimenthylaminophenol—The sulfate crystallizes in hexagonal tablets which are extremely soluble in water. The oxalate is moderately soluble in water and alcohol; it melts at 187° to 191°. The free base is fairly readily soluble in cold water; it melts at 75° and is extremely soluble in ether. On allowing a solution in sodium hydroxide to stand in air the same dark color and pyridine-like odor are developed as with the monomethyl compound. On adding sodium nitrite to a solution in dilute acid, a reddish brown coloration is formed, with evolution of gas. On adding a saturated solution of potassium ferrocyanide to a fairly concentrated solution in dilute sulfuric acid, a white crystalline precipitate of the acid ferrocyanide soon separates. It forms an acetyl derivative melting at 78°, and a benzoyl derivative (soluble in dilute acid) which melts at 158°.

o-Methylaminophenol—The sulfate crystallizes in stout needles which are extremely soluble in water; the free base, which is slightly soluble in cold water but readily so in hot water, crystallizes in leaflets melting at 96°. It dissolves in alkali, forming a solution which slowly darkens to a dull green color on standing in air, giving a pyridine-like odor, but more slowly than the para compound. The free base and its sulfate are completely soluble in three parts of concentrated hydrochloric acid. On adding sodium nitrite to a solution in dilute acid, the nitrous compound is precipitated in colorless leaflets which melt with decomposition about 130° after darkening from 120° onwards (the melting point is rather indistinct and depends upon the rapidity with which the bath is heated). The derivative obtained on acetylation is a liquid which dissolves in cold water; on gentle hydrolysis by warming with dilute alkali it yields the monoacetyl compound (soluble in alkali and precipitated by acid) which melts at 150°. The dibenzoyl derivative melts at 113°.

p-Phenylenediamine—The hydrochloride crystallizes in leaflets which are readily soluble in water. The free base, melting at 140°, is moderately soluble in cold water and sparingly in ether. On adding to a cold dilute solution an excess of sodium acetate and then a few drops of benzaldehyde, the pale yellow dibenzylidene derivative is precipitated; this crystallizes from methyl alcohol, in which it forms a bright yellow solution, in thin leaflets, melting at 138°. Both the diacetyl and dibenzoyl derivatives melt at temperatures too high for convenient measurement.

QUANTITATIVE METHODS.

It frequently happens that photographic developers placed upon the market consist of mixtures of developing agents or of impure simple substances, so that it may be necessary to separate and estimate the constituents of a mixture or to determine the purity of a sample of a single substance.

Group I—No direct method for determining the purity of a sample of *p*-hydroxyphenylglycine is available. An ash determination should be made, and the amount of matter insoluble in dilute sodium carbonate estimated. If a sulfite be present the sulfurous acid liberated by mineral acid should be determined by the method indicated below.

Group II—All the substances in this group should leave no ash on ignition; if there be any, it should be estimated. Likewise all should dissolve in water and in ether without residue, and should leave no considerable residue when the main constituent is volatilized under atmospheric or reduced pressure.

The melting point forms a fairly satisfactory criterion of the purity when the sample is found to be completely soluble in ether.

The proportion of hydroquinone in a sample of chlorohydroquinone may be estimated by isolating and weighing the matter insoluble in warm benzene.

Groups III and III*a*—Water-insoluble material and ash should be estimated; in Group III the amount of matter insoluble in alcohol should also be determined. The proportion of chloride, sulphate, sulphite, etc., should be determined; and in certain cases it may be well to estimate the total nitrogen by the Kjeldahl method, making certain, of course, that free ammonium salts are absent.

It is important in all cases to determine the amount of salts of *p*-aminophenol or aminocresol present, both in samples consisting principally of one of these compounds and in samples of methylated derivatives. The procedure is as follows:

Ten grams of the sample are dissolved in about 150 cc. of cold water (or, in the case of the free base, dilute hydrochloric acid). Heating must be avoided, since this may cause impurities to enter into solution which do not again separate on cooling. A slight excess of sodium acetate is then added, and to the cold solution about 10 cc. of benzaldehyde are run in. When the sample contains a relatively small proportion of aminophenol, as in samples of *p*-methylaminophenol sulfate, the amount of benzaldehyde should be considerably reduced. After standing over night the mixture, which should still contain excess of benzaldehyde, is filtered by suction, the solid well washed with water, dried in the steam oven, and weighed. A Gooch crucible answers satisfactorily.

The following factors are applied for expressing the result:

As p-aminophenol hydrochloride	0.738
As *p*-aminophenol sulfate	0.802
As *p*-aminophenol base	0.554
As 5-amino-2-cresol hydrochloride	0.756
As 5-amino-2-cresol sulfate	0.815
As 5-amino-2-cresol base	0.584

For the remaining substances in this group the simple though non-specific total nitrogen content must be determined and the assumption made that all the nitrogen is in the form of the pure substance.

INORGANIC RADICLES.

When an ash has been found and shown to consist of a salt of an alkali metal, a weighed sample of the substance should be ignited in a platinum crucible and the residue repeatedly evaporated to dryness and heated to redness after adding a few drops of 20 per cent. sulfuric acid; in this way the metal is completely converted into the sulfate.

Chlorides and bromides should be determined by the Volhard method. Direct estimation of alkali carbonate is difficult or even impossible in some instances, and may have to be effected by difference.

Sulfites are best estimated by distilling an acidified solution of the sample into alkali and titrating the distillate against standard iodine solution, running the sulfite into the iodine. A regular Kjeldahl distillation apparatus answers well for the purpose.

TYPICAL ANALYSES.

For obvious reasons the sources of the material used for these typical analyses are not indicated; they represent a selection from a very large number performed in the years 1916-1918.

"*Mq*" *Developer Tube* (April, 1916)—The total weight of material in the compartment containing the developing agent was 0.6276 g. This was placed on a filter and well washed with ether; the ethereal solution, on evaporation, left pure hydroquinone; the insoluble residue, when dried at 100°, weighed 0.1241 g. and was found to consist of pure *p*-methylaminophenol sulfate. The hydroquinone was not weighed, but estimated by difference.

"*Mq*" *Developer Tube* (April, 1916)—A similar analysis on another tube showed total weight 0.5713 g.; ether-soluble material consisted of pure hydroquinone; ether-insoluble material weighed 0.1120 g. and consisted of technically pure p-aminophenol hydrochloride.

Developing Agent (March, 1916)—The material was a light brown powder of rather moist appearance. It contained no substance soluble in ether, but dissolved partially in alcohol, the alcoholic extract depositing *p*-aminophenol hydrochloride on evaporation. 2.000 g. were boiled with alcohol and filtered on a weighed Gooch crucible. The insoluble residue was well washed with hot alcohol and dried to constant weight *in vacuo* over sulfuric acid. It weighed 0.728 g. and consisted of pure starch. The filtrate was evaporated to dryness and the residue dried at 115°; it weighed 0.998 g. Another 2.000 g. sample was heated in the oven at 115° to constant weight; it lost 0.308 g.

The material thus consisted of

	Per cent
p-Aminophenol hydrochloride	49.9
Starch	36.4
Moisture	15.4
	101.7

"*Metol*" (April, 1918)—This consisted of technical *p*-aminophenol hydrochloride, without a trace of methylated product.

"*Metol*" (April, 1918)—The label claimed the contents to be "Hydrochloride of methyl-*p*-amino-*m*-cresol guaranteed 96.3 per cent. pure." The material consisted entirely of 5-amino-2-cresol hydrochloride, without a trace of methylated product.

"*Metol Substitute*" (April, 1916)—The material was first extracted with ether, and the filtrate found to contain only pure hydroquinone. 2.7654 g. gave 0.5122 g. of hydroquinone, or 18.5 per cent. The residue showed the presence of sulfite and sulfate as the only acid radicles; on ignition, a residue consisting of sodium salts was left. *p*-Methylaminophenol was found by the usual methods, and the behavior of the material led to the suspicion that cane sugar was present. This was confirmed by boiling with strong hydrochloric acid, when the characteristic brown color and odor of caramel were developed. Further examination failed to show the presence of other substances.

The portion insoluble in ether was dissolved in water and diluted to 50 cc.; this solution in a 20 cm. tube gave a rotation of 2.90°, using mercury green light, corresponding to 0.932 g. cane sugar in the sample, or 33.7 per cent.

Another portion of the original sample was ignited in a platinum crucible and the residue converted into sodium sulfate; 1.3604 g. gave 0.5319 g. of sodium

sulfate, corresponding to 34.7 per cent of sodium sulfite. (The sulfurous acid content was not determined as a check.)

For estimating the *p*-methylaminophenol sulfate, a portion was digested with sulfuric acid and the nitrogen determined by the Kjeldahl process; 1.4880 g. required 8.6 cc. of N/10 acid, corresponding to 0.148 g. *p*-methylaminophenol sulfate, or 10 per cent.

The material thus contained:

	Per cent
Hydroquinone	18.5
Cane sugar	33.7
Sodium sulfite	34.7
p-Methylaminophenol sulfate	10.0
	96.9

"*Metol Substitute*" (June, 1916)—The material on treatment with ether yielded a soluble constituent which was identified as pyrogallol; the residue, which contained no nitrogenous matter, consisted entirely of sodium sulfite; the ethereal extract from 5.1215 g. gave, on evaporation, 1.3050 g. of pyrogallol or 25.5 per cent.; the residue was acidified and the sulfurous acid distilled into alkali, which was then diluted to 200 cc. Of this solution 15.9 cc. were required by 60 cc. of standard iodine solution, equivalent to 50.0 g. sodium sulfite per liter, corresponding to a total of 3.773 g. sodium sulfite, or 73.8 per cent. Another sample was ignited with sulfuric acid: 1.2730 g. gave 1.0455 g. sodium sulfate, corresponding to 0.9280 g. sodium sulfite or 72.9 per cent.

The material thus consisted of:

	Per cent
Pyrogallol	25.5
Sodium sulfite	73.4
	98.9

Developing Agent (July, 1916)—Ether dissolved out a small amount of dark smeary material, which was not further investigated. The residue, on further examination, was found to consist of impure *p*-aminophenol hydrochloride mixed with lead chloride and a small amount of lead sulfate. The lead was determined by ignition with sulfuric acid: 1.7130 g. gave 1.1270 g. of lead sulfate, or 0.429 equivalent of lead per 100 g. of sample. In another sample chlorine and nitrogen were determined by collecting in alkali the gases evolved on heating with sulfuric acid in the Kjeldahl process: 1.6070 g. were heated with 25 cc. of sulfuric acid, the gases evolved during the early stages of digestion being absorbed in 25 cc. of 10 per cent. alkali. This was diluted to 100 cc. 10 cc. of the solution required 22.6 cc. of N/20 silver nitrate after deducting the blank test, corresponding to 0.710 equivalent of chlorine per 100 g. of sample. The ammonia required 46.4 cc .of N/10 acid, corresponding to 0.289 equivalent per 100 g. of sample. Deducting this leaves 0.421 equivalent of chlorine combined as lead chloride; again deducting, there remains 0.008 equivalent of lead sulfate.

Composition of 100 g. of sample:

	Per cent
Impure *p*-aminophenol hydrochloride	0.289 equivalent or 42.1
Lead chloride	0.421 equivalent or 58.5
Lead sulfate	0.008 equivalent or 1.2
	101.8

The above analysis is of course accurate only to about 1 or 2 per cent., especially in the figure for *p*-aminophenol since all nitrogenous matter has been calculated as *p*-aminophenol hydrochloride.

Developing Agent (September, 1916)—This material was stated by its label to be "Identical to Metol." On treatment with ether a considerable quantity entered into solution; the ethereal extract, on evaporation, left hydroquinone: 1.2140 g. gave 0.6300 g. or 52.0 per cent. of hydroquinone. The insoluble portion was found to contain sulfite, sulfate, carbonate, iodide, sodium, potassium, and a salt of *p*-methylaminophenol.

Iodine estimation: 0.8996 g. gave 0.0613 g. AgI. Expressed as potassium iodide, 0.0487 g., or 5.4 per cent.

Sulfite estimation: 1.2140 g. required 36.0 cc. of standard iodine solution (1 liter corresponding to 50.0 g. of anhydrous sodium sulfite) corresponding to 0.179 g. or 14.7 per cent. sodium sulfite.

Alkali metals: 0.2135 g. gave 0.0512 g. mixed sodium and potassium sulfates. This corresponds to 5.4 per cent. potassium iodide plus 14.7 per cent. sodium sulfite plus 3.7 per cent. sodium carbonate.

Nitrogen estimation (Kjeldahl): 0.6030 g. required 11.5 cc. of N/10 acid, corresponding to 0.198 g., or 32.8 per cent. of *p*-methylaminophenol sulfate.

Composition:

	Per cent
Hydroquinone	52.0
p-Methylaminophenol sulfate	32.8
Sodium sulfite	14.7
Potassium iodide	5.4
Sodium carbonate	3.7
	108.6

Metol Substitute (June, 1918)—The material was extracted with ether, which, on evaporation, left no residue. Methyl alcohol dissolved a considerable proportion; the filtrate, on evaporation, left a residue consisting of pure ammonium *p*-toluenesulfonate, which was identified by the preparation of the corresponding sulfonic chloride and sulfonamide, both of which had the correct melting points. Further examination showed the presence of a salt of *p*-methylaminophenol and a small amount of some sodium salt. Sulfate was found to be present.

As ammonium *p*-toluene sulfonate has no developing action, the principal interest lay in the proportion of *p*-methylaminophenol present. A weighed quantity was accordingly dissolved in water and heated to boiling. To the boiling solution an excess of sodium carbonate solution containing a small amount of sodium sulfite was added, and the mixture boiled until every trace of ammonia was expelled. The residue was then immediately acidified with dilute sulfuric acid, and the nitrogen determined by the Kjeldahy method: 0.1200 g. required 8.5 cc. of N/10 acid corresponding to 0.146 g., or 12.0 per cent. of methylaminophenol sulfate. The material thus contained 12.0 per cent. *p*-methylaminophenol sulfate, the remainder consisting of ammonium *p*-toluenesulfonate together with a small proportion of sodium salts.

Adulterants—These are of such diverse nature that it is impossible to suggest any general lines of examination. Among the adulterants and useless substitutes the following have been encountered:

Starch	Potassium bromide	Sodium carbonate
Cane sugar	Potassium iodide	Ammonium chloride
Citric acid	Potassium nitrate	Ammonium sulfate
Sodium formate	Sodium chloride	Calcium sulfate
Potassium oxalate	Sodium sulfate	Magnesium sulfate
Rochelle salt	Sodium sulfite	Lead chloride
Potassium ferrocyanide	Sodium bisulfite	Lead sulfate
	Sodium sulfide	
Boracic acid	Sodim hydroxide	
Borax		

Research Laboratory, Eastman Kodak Company, Rochester, New York.

The Preparation of Xylose from Corn Cobs

In a previous article we published directions for preparing pure crystalline xylose from cottonseed hulls. As the yield was relatively large, namely 8 to 12 per cent, it seemed that these hulls were an ideal source for xylose. Later experiments have shown, however, that corn (*Zea mays*) cobs are even a better source. The yield is uniformly good, about 12 per cent, the crude xylose is of high purity, and the solutions throughout the course of preparation are less colored than those from cottonseed hulls, even though the preliminary cleaning of the hulls with weak ammonia is omitted when corn cobs are used. It has been shown by Stone and Lotz that crystalline xylose can be prepared from corn cobs, but their yield was less than one per cent. Their method involved the separation of xylan from the cobs and its subsequent hydrolysis to xylose.

The method that has given good results, in the preparation of many kilograms of xylose at different times in this laboratory, is the following:

Seven hundred and fifty g. of broken but not necessarily ground corn cobs are boiled two hours with 6 liters of 7 per cent sulfuric acid under a reflux condenser. The insoluble residue is filtered off, and the absorbed liquid is pressed out of the cobs with a hand press. The filtrate is exactly neutralized with pure calcium hydroxide, care being taken that the reaction never becomes alkaline. The calcium sulfate is filtered off, washed with hot water and the washings combined with the filtrate. The filtrate is made just acid to litmus with phosphoric acid, and is decolorized with carbon or bone char, about 30 g. decolorizing carbon being required. The filtrate is boiled under reduced pressure to about 0.5 liter and to it two volumes of 95 per cent ethyl alcohol are added to precipitate the remaining calcium sulfate. After filtration the solution is boiled under reduced pressure to a very thick sirup of 85-90 per cent solids. Should it begin to darken while boiling it may be removed when at about 400 cc. volume and decolorized again. To the sirup sufficient 95 per cent ethyl alcohol is added to cause the sirup to be nearly saturated with alcohol after the homogeneous mixture cools to room temperature. An excess of alcohol causes the separation of two liquid phases. This saturation requires approximately 50 cc. alcohol. During the progress of the crystallization at room temperature or lower more alcohol may be added to prevent the mass from becoming solid, but care should be taken that sirup is not precipitated. Crystallization is usually complete in from two to three hours, but the solution is ordinarily allowed to stand overnight at 0 degree. The crystals are filtered off, washed successively with 75 per cent, 95 per cent, and absolute alcohol and dried in a vacuum oven. The sugar is in many cases colorless and pure and the yield is between 10 and 12 per cent, depending upon the cobs that are used. If required, the crude xylose may be recrystallized from water or aqueous alcohol.

In conclusion, we would add that xylose is one of the most easily prepared members of the sugar group when either cottonseed hulls or preferably corn cobs are used as its source. There should no longer be any difficulty in obtaining a supply of this pentose sugar for chemical, bacteriological, medical or other scientific uses.—*Contribution from the Carbohydrate Laboratory, Bureau of Chemistry, United States Department of Agriculture by C. S. Hudson and T. S. Harding in Jour. Am. Chem. Soc.*

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